THE

ENGINEERING MAGAZINE

VOL. XVIII. MARCH, 1900. No. 6.

GOLD-MINING PROSPECTS IN RHODESIA.

By R. R. Mabson.

PRIOR to the granting by the British Government of a charter to the British South Africa Company (or, as it will be termed in any future remarks, the Chartered Company) the belief existed that the region north of the Transvaal and south of the Zambesi contained minerals in profusion, and especially gold. The country was visited by representatives of syndicates and individuals seeking concessions to search for minerals. Without going minutely into the history of the Chartered Company, it may be stated that its first objective was to secure mining rights over Mashonaland, and eventually, after a series of incidents recalling characters and events that would make a highly flavoured novel, Lobengula conceded rights to the initiators of the company and the charter was secured. An armed expedition proceeded to the Mashonaland field, establishing in its progress camps at Tuli, Victoria, Fort Charter, and Salisbury. One of the first administrative acts of the new company, after it had established itself and obtained the sinews of war in the form of share subscriptions, was to formulate a gold law, and various districts, principally in the neighbourhood of the north and west of Salisbury, were explored and areas were pegged out as gold claims. The area of claims at first was fixed at 150 ft. along the strike of the reef by 200 ft. each side, or in all 400 ft. across the reef outcrop. Subsequently—but this is a detail—the area was modified to 300 ft. each side of the reef, or 600 ft. across, the length on the strike of the reef remaining unchanged.

The initial idea was that, as mines were started, the Chartered Company, as ground landlord, was to get 50 per cent. of the vendors'

For the illustrations accompanying this article, we are indebted to the courtesy of the British South Africa Company. Mr. Mabson's paper sustains the interest in South African affairs which marked the contributions of Messrs. Albert Williams, Jr., H. G. Prout, and John Hays Hammond in recent issues of THE ENGINEERING MAGAZINE.

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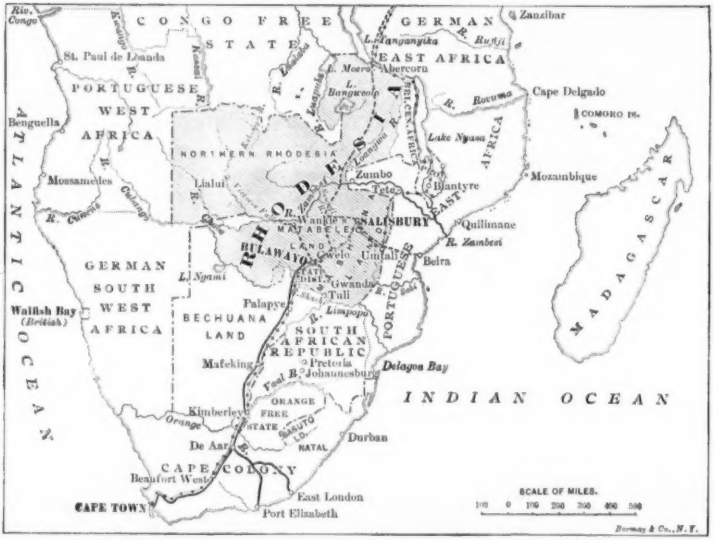
scrip; and, as the plan has been much referred to, a few words of detail may be given as to what the "50 per cent." really meant.

If it be assumed that a mining company were formed with a capital of £200,000, £150,000 being applied as scrip for the property and £50,000 for working resources, the outcome of the transaction would be:

Nominal capital, £200,000	{	To venders,	£75,000
		To Chartered Company,	75,000
		For working capital	50,000

In course of time the percentage was modified, and in recent times

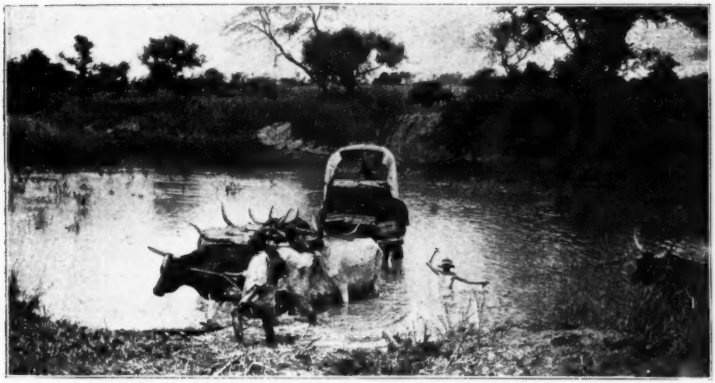


MAP OF RHODESIA AND ADJOINING PORTIONS OF SOUTH AFRICA.

an average of about 30 per cent. has been handed to the Chartered Company on like procedure to that set out above.

Exploration companies owning large areas scattered over the country proceeded to development, found likely areas, formed sub-companies to mine, and the scrip proportion was in respect of the latter class of company. The big exploration and landholding companies occasionally did a "deal" with the Chartered Company, and compounded for any sub-flotations of mines by handing it an agreed proportion of the exploration company shares.

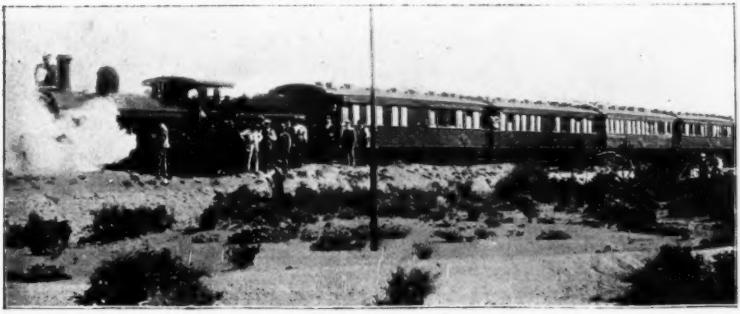
Ab initio, the Chartered Company has had the backing of a large



EARLY TRAVEL IN RHODESIA.

section of the public, both in Great Britain and on the Continent—about the beginning of 1899 it had more than 40,000 shareholders, and some 10,000 of them Continental holders. It has had likewise not a few adverse critics—the latter either believing or professing to believe that the public was being deceived, or holding forth that it was sinful to take over and civilise a country that had till the end of the nineteenth century been *terra incognita.*

Taken from the business point of view, while a great number of persons credited the assertions as to the existence of payable gold propositions, a great number professed the entirely opposite belief. Many, indeed, went so far as to say that no gold whatever existed. Subsequently, on proof being afforded by actual experience that there was



TRAIN ON THE LINE TO BULAWAYO.

gold, assertions were made that, though there might be gold, there was no gold in payable quantity. Not, indeed, until late in 1898, when a start was made on an extended scale in milling gold, were the original pessimistic theories dispelled. But this is going a little in advance of events. The vehement assertions of the non-existence of gold were for a long time supported by the fact that year after year passed without its production. The first property pegged out bore date 26 Sept., 1890. That property, and in round figures approximately 90 per cent. of the properties which were pegged out subsequently, were selected by the original prospectors for the reason that they contained "old workings." Prospecting operations were greatly facilitated over large stretches of country by the discovery of excavations, about which a great deal remains to be ascertained. It has been maintained that

A GROUP OF NATIVES.

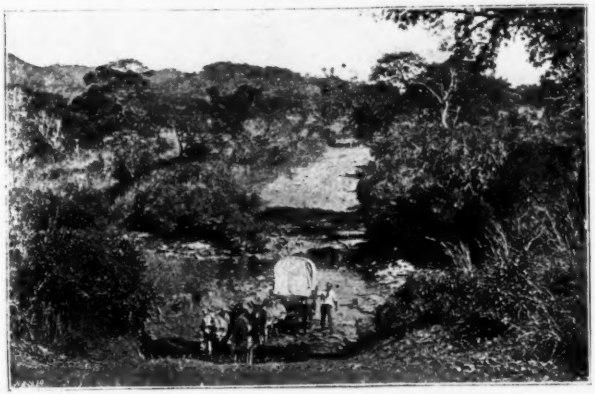
some of the excavations were made by the ancient Phœnicians. Remains of buildings have been discovered in which gold ornaments have been found, and those buildings are believed to date, in some instances, from three thousand years ago. They certainly were never constructed by the ignorant black population.

The evidences have been too numerous and palpable for close observers of the gold industry to credit assertions that the enormous ancient pits and stopes, existing in Rhodesia, were other than man's handiwork. Furthermore, mining operations have completely dispelled the vehement assertions that have at times been made that, even granted the excavations have been effected by ancient diggers, all the gold had been extracted. The disproof of this has been ample.

GOLD ORNAMENTS FOUND IN ANCIENT RUINS, RHODESIA.

SALISBURY FROM THE KOPJE.

PIONEER STREET, SALISBURY.

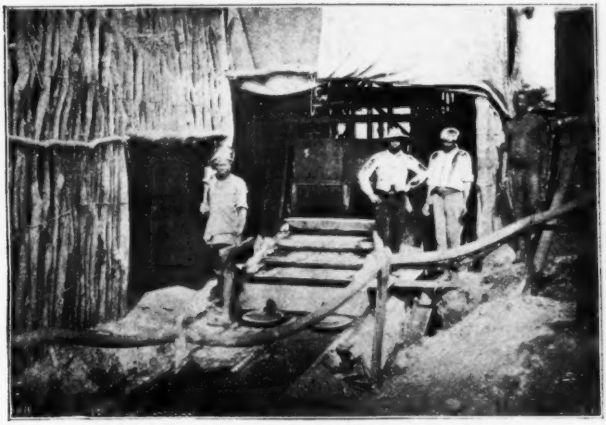


IN THE MATOPPO HILLS, SOUTHERN RHODESIA.

A TRANSPORT WAGON IN PIONEER DAYS.

Geological experts who have visited the country have repeatedly announced that the lodes are true fissure veins, *i. e.*, that the gold-bearing reef continues indefinitely into the ground. It is to be recollected that the ancient miners, even if but decades instead of centuries ago, had

LOBENGULA'S BATTERY, UMFULI RIVER.



LOBENGULA'S FIVE-STAMP BATTERY, HARTLEY, 1892.

only primitive appliances for working. When they delved into the earth they attained, so far as I could learn, (and I visited some fifty developed properties during my journeyings through the conutry,) the utmost depth of about 250 ft. and perhaps an average depth of

some 100 ft. In the Geelong mine—which by the way is in Matabeleland, south-east of Bulawayo—the greatest depth was attained. Now at depths varying from 100 to 250 ft. from the surface oxidation ceases. The action of the air over countless centuries disintegrates

ANCIENT STOPE, GEELONG MINE.

the pyrites and makes the gold contained in the ore far more readily treated than is the case below a zone of, say, 100 to 250 ft., where the sulphide ore is come upon.

The cessation of work by the ancients may be put down to three causes. Taking the Geelong mine for example, first, it may be that at such depth as 250 ft., water was an insuperable obstacle in the absence of pumping appliances; next, it may be that, even were the mine dry, when the workers passed from the oxidised to the sulphide zone they came upon ore from which, with their rough appliances, they could not extract the gold; thirdly, work may have been stopped by the wholesale massacre of the workers. This is the explanation generally accepted. Be this as it may, the first two suggestions are quite sufficient to account for the lode being followed only to a comparatively slight depth. But this leads to the next point—refutation of the statements that the gold was all worked out, and that that was the reason why no further depth was attained. This theory will not hold water for an instant, and for this reason. Reverting to the Geelong mine, which is very typical: at the time of my visit to the property in June last, I found the shaft on the incline of about 45 degrees had been carried down very nearly 600 ft. The deepest old working, as I have mentioned, was 250 ft.; consequently, gold-bearing ore was be-

ing mined and milled which was derived from a depth of, say, 300 ft. below the deepest of the old workings.

It may be convenient here to mention the further evidences of operations having been conducted in the old workings which for a time were alleged by some theorists to be only nature's handiwork. When I went into the Geelong ancient stopes (which are left intact) I spent a considerable time fossicking about at depth. My object was to see, as far as I could, the traces of man's handiwork. I was perhaps better able to discern points which might have escaped the ordinary observer from having, as a pastime, studied the evidences of flint implements of prehistoric man in the British Isles.

I was happy, in turning over the débris, in coming upon two granite balls, bearing evidences of having been used as hammers, almost exactly round and about the size of the two hands clenched. In parts, the ancient stopes were very narrow, and one had to penetrate to cavities [stopes] of not more than two or three feet from roof to footwall. In other parts the stopes were quite cavernous. In the latter, the wall was frequently alcove in character, smooth, and in parts still black from smoke, and amongst the débris were remains of charcoal. It is believed (and I can quite credit the theory) that the procedure of the ancients was to light fires in the stopes, and then, when the gold-

BATTERY SITE, GEELONG MINE.

bearing rock cooled, to use granite hammers to break down the ore. To go further, the chipped-off gold-bearing rock would probably be put into native baskets and carried to the surface. Though not noticeable at the Geelong, at other mines—the Bonsor, the Red and White

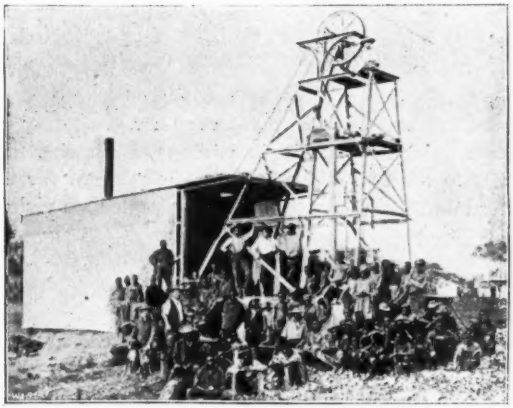
Rose, and one or two others—I found occasionally at the top of kopjes, or little hills, where there were large masses of hard rock, patches of indentations in flat areas of rock, just as though mortars had been sunk into the rock. I was shown, on some properties, smaller granite stones picked up in the vicinity of the rock pots. One can imagine the women bearing baskets of broken ore from the mine to the top of the kopje, where other women were seated crushing the ore with the granite balls in the pots. Beside the pots were numerous slight elongated indentations, recalling those which the verger at Canterbury Cathedral shows to visitors as having resulted from the scraping of soles of pilgrims' feet when they genuflexed at the shrine. It would seem from other rock implements of grinding character that the indentations were made in the process of grinding the rock flakes into a powder, after the rock, roughly broken out in the stopes, had been broken up small.

How did the ancients ultimately extract the gold? The answer to this is that, in nearly all cases, mines are near pools or streams, and frequently by the sides of these bodies of water are found rock pots somewhat similar to those found on the kopjes. We can imagine that the powder was deposited in these rock pots, flushed with water, the sand driven off, and the gold, sinking to the bottom, was eventually collected. Even in the present days, one can buy, in Portuguese territories, little quills containing gold flakes and dust.

We may now return to the history of gold production in Rhodesia. From 1889 to 1898 is a long period to elapse before the stage of commercial production is reached, especially in these days of Anglo-Saxon energy. The long delay was in part due to the fact that there was more disposition to speculate in gold-mining shares than to settle down to hard work, though it will be noticed the first property was only selected late in 1890. A great number of companies were formed at the time of the granting of the charter to the British South Africa Company, or shortly afterward. In order to comply with the gold law and secure title, a certain amount of work had to be done in a given time. The original prospectors pegged out claims, sought soft spots on which to sink shafts—generally in old workings—attained a depth, in the average, of about 80 ft., proved the existence of gold, and disposed of their properties to capitalists, who in turn floated companies. Extravagant prices in shares were sometimes paid for properties; other shares were issued for working capital; but the proportion between working capital and purchase price was generally far too one-sided, and the outcome was inadequate resources for develop-

ment. Moreover, just when the companies were reaching the stage of setting seriously to work, came the struggle between the whites and Lobengula's hordes, necessitating the withdrawal of whites from the mines, their concentration, and the advance from Mashonaland into Matabeleland. This was in 1893. A great number of the men who had devoted themselves to the exploitation of Mashonaland, when they reached what they conceived to be a land of greater promise, stopped there. Mashonaland for several years was all but deserted, and the new field of Matabeleland alone had energetic attention given to it. There was a repetition of the process of fossicking, pegging, provisional development, and flotation.

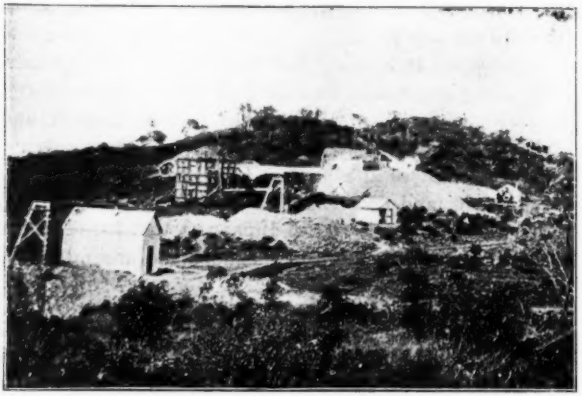
The region east and south-east of Bulawayo was found to contain larger and richer reefs than those in Mashonaland around Salisbury.



VULTURE REEF, GWANDA DISTRICT.

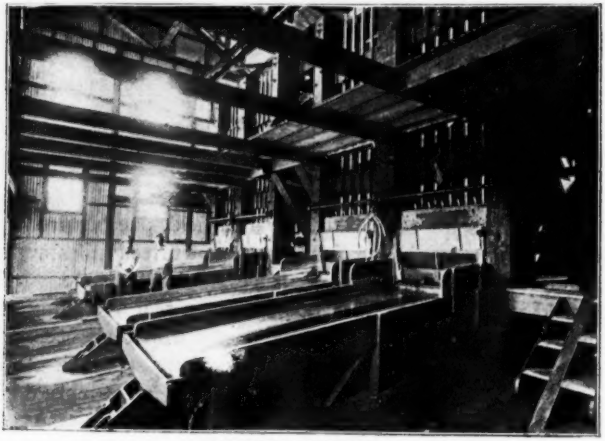
In especial was this the case in the Gwanda field, one hundred miles south-east of Bulawayo, in the Sebakwe, about fifteen miles north of Gwelo, and the Selukwe, a like distance south of Gwelo. In the Gwanda field are situated the Geelong, having a reef averaging 15 ft. thick, and Nicholson, with double reefs, one of which has been developed to such an extent as to prove that for a long stretch it contains reef west of the river averaging 30 ft. and running up to more than 50 ft., and east of the river averaging 50 ft. and running up to more than 60 ft. wide. This is one of two parallel reefs. Further east of the river the continuation of the reef has been ascertained quite recently to expand to a width of about 100 ft. and assays have led experts to offer the opinion that an extraction of ½ oz. of gold to the ton will be

secured. The line of the reef extends for miles. In the Sebakwe district is the Globe and Phœnix mine, on the eve of making a start with its mill. There, for a stretch of about 1,250 ft. there is a rich



ANTENIOR MINE, GWANDA DISTRICT.

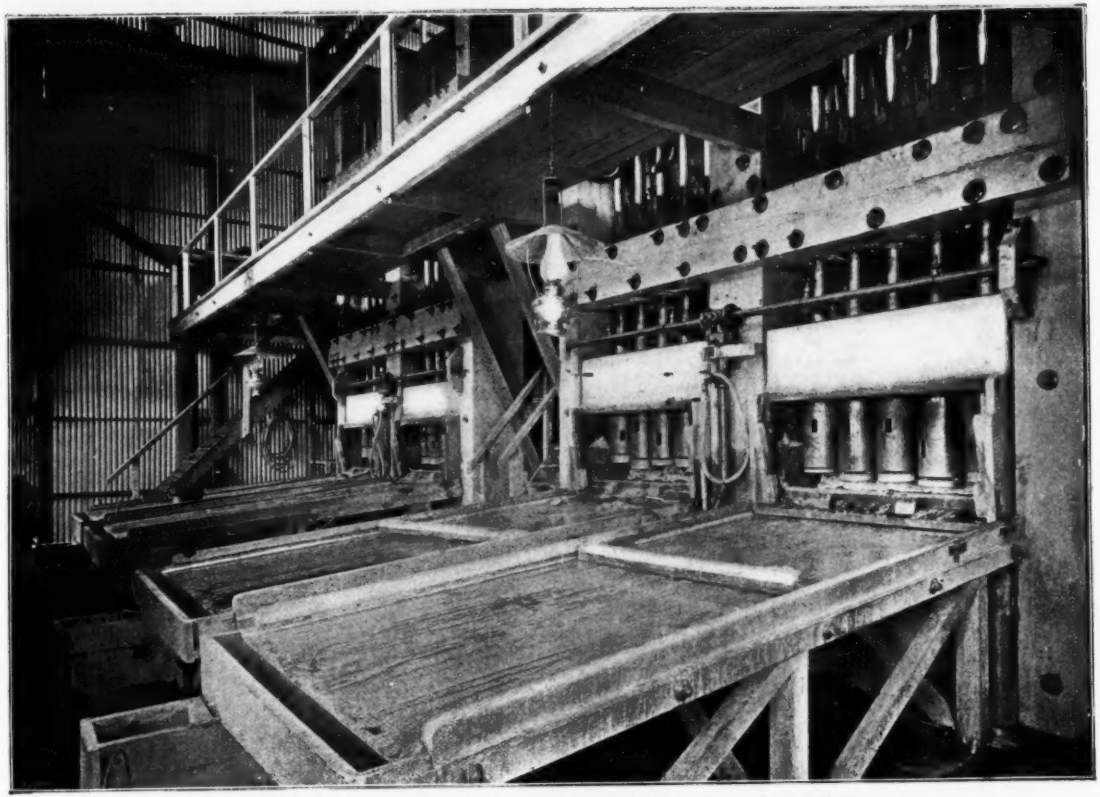
chute of ore, averaging about 19 in. in width and showing assays of nearly 3½ ozs. to the ton. This is the show mine of the field, but there are other mines being opened up in the immediate vicinity. To



DUNRAVEN BATTERY.

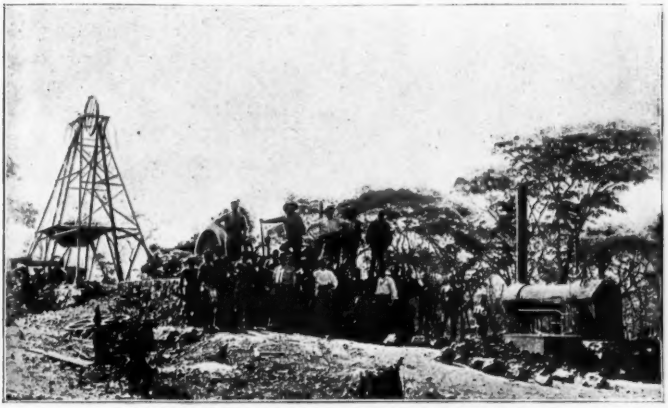
the south of Gwelo, the Selukwe (or, as it used to be termed, Tebekwe) mine has shown very rich results and has been largely developed. Near it are the Bonsor and the Dunraven properties.

GENERAL VIEW OF TEBEKWE MINE, SELUKWE GOLD-MINING CO.



INTERIOR OF BATTERY HOUSE, TEBEKWE MINE, SELUKWE GOLD-MINING CO.

Milling results have lately been given by the Geelong and Antenior, in the Gwanda district; the Selukwe, Bonsor, and Dunraven, in the Selukwe district; and the Globe and Phœnix, in the Sebakwe district. All these mines, doubtless, would have become producers at a much earlier stage than late in 1898, but for the fact that Matabeleland, like Mashonaland in 1893, had in 1896 a native trouble, and prior to that trouble there was the terrible scourge of the Rinderpest—a scourge which has scarcely been appreciated outside of South Africa. For instance, I went over one farm in Matabeleland, where, prior to the outbreak of rinderpest, there were eight thousand branded cattle. When I was there in 1899 there were only eighty small imported cattle, chiefly from Madagascar. Oxen, in the old days, used to provide the sole mode of transport. The rinderpest plague broke out early in



HEAD GEAR, GLOBE AND PHOENIX MINE, SEBAKWE.

1896, and when it was at its worst as to demoralisation of the natives the Matabele rising occurred. The second native trouble broke out in March, 1896, and the white population, outside of centres like Bulawayo and Gwelo, had to concentrate at these points, and mining was necessarily temporarily abandoned.

Rhodesia, as a whole, is patchy as to geological characteristics, granitic and schistose formations alternating. One encounters stretches of granite country, with wearisome "roads" of loose disintegrated granite sand, and emerges from such a tract into a schistose red-earth country. The gold areas are almost exclusively in the schistose formation.

The intermittent areas of schistose ground extend over a very large

mileage—quite three hundred miles in a trend from north-east to south-west, and from one hundred to one hundred and fifty miles from south-east to north-west.

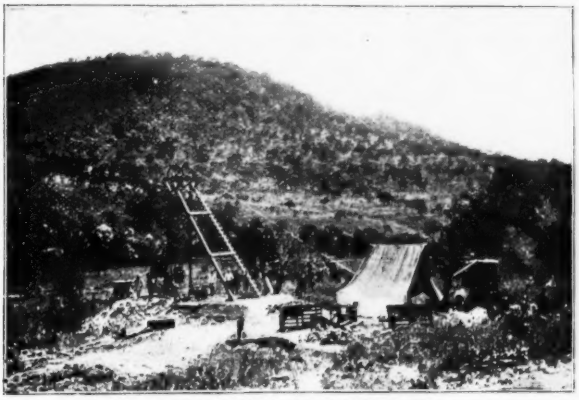
In one of Mr. Rhodes' addresses to the shareholders of the British South Africa Co.—in May, 1899—that gentleman mentioned that the total number of claims which had been registered in Rhodesia exceeded one hundred and thirty thousand. As I have stated, approximately nine claims out of ten have been selected because of the existence on them, or near them, of ancient workings. Were the claims on the run of the reef *i. e.*, 150 ft. each claim—placed side by side in one continuous line, such claims would reach about as far as from Chicago in a direct line to London.

HEAD GEAR, CHRISTMAS REEF.

In Rhodesia, as in America, mining companies are permitted to "follow" the reefs through all the dips, angles, and spurs. This is not the case in West Australia nor in the Transvaal, where one can follow the reef only to the extent of the surface ground and cannot mine beyond the limit of a vertical line sunk from the frontier of the surface. The difference in the procedure of mining under the Transvaal and the Rhodesian law means something very considerable. With the reef inclining into the earth at an angle of about 30 degrees, and continuing indefinitely, one Rhodesian claim containing the outcrop of the reef, and followed to easily practicable mining depth, would give the right to extract from a reef of 3-ft. thickness, about 222,000 tons. The same

surface area of a Transvaal mine under like conditions of dip and thickness would give the enterprise under the Boer law a right to extract less than 12,000 tons. What, then, may be expected from claims in Rhodesia like those found to exist in the Gwanda district, having a reef 15 ft., 30 ft., 50 ft., or even 100 ft. thick?

PENHALONGA BATTERY, NEAR UMTALI.



CHRISTMAS REEF, NEAR BULAWAYO.

There is not in Rhodesia, as in the Transvaal, the same eagerness to secure what is termed "dip ground." As pointed out, in the Transvaal the area containing the outcrop of the reef alone can be mined under by the company having possession of property in which the reef outcrops. Beyond the frontier of such area, any company which

wishes to tap the continuance in depth of the same reef has to acquire the portion of ground adjacent to the outcrop area, sink a vertical shaft, come upon the reef, and work it. A third or a fourth company of like "deep" character may secure ground in which, at further depth, the reef may exist. With the ability of Rhodesian miners to "follow" the reef indefinitely, acquisition by companies has been confined to ground actually containing, or believed to contain, the reef outcrop. Given that, of about 3,700 miles along outcrop claims, only 5 per cent. contain payable reef, the possibilities as to the future of Rhodesia are enormous.

We have many proofs, in widely separated districts, that the reefs are payable—proofs as instanced twenty miles north and about twenty miles south of Gwelo, and proofs from approximately seventy miles almost due south to a point one hundred and twenty miles south-east of Bulawayo. The run of the reefs in the latter district indicates an almost uninterrupted continuance for a distance of about twenty miles,

AYRSHIRE MINE.

from the Antenior mine with paying mill results, on the west, to the Geelong mine with like paying results on the east; and beyond, south-east of the Geelong some ten miles further in the same trend, are the Nicholson reefs.

There has been no call so far for prospectors to search for reef formations in virgin ground. Hence so small a proportion of what has been selected as reef-bearing is of virgin character. The ancients were good fossickers, but it is conceivable that many areas containing reef escaped their notice.

A deterrent to the mining industry in the past has been the want of transport facilities. Bullock-wagon transport has been costly and slow, and indeed the sending of boilers and heavy machinery in some districts was not attempted, owing to the huge expense. Railway construction, however, is greatly facilitating the equipment and supply of mines. The bulk of the heavy work has been effected since the opening, in November, 1897, of the railway from Cape Town direct to Bulawayo, and the Salisbury district in May, 1899, was connected by railway via Umtali with Beira on the east coast. Early in 1899, arrangements

CONSTRUCTION WORK ON THE MASHONALAND RAILWAY.

were entered into for building a line of one hundred miles from Bulawayo to the Gwanda gold district, and it will be extended to Tuli to tap the coal area there. Again, from Bulawayo in a north-easterly direction a road is being built to Gwelo to give access to the districts in that vicinity. Surveys are now being made for a road to connect Salisbury via Gwelo with Bulawayo. There is also a railway projected from Bulawayo to the coal and timber areas north-west. The railroads mentioned will all be of standard 3 ft. 6 in. gauge, and the probability is that feeder light lines to mine districts will be built in course of time.

Given restoration of peace to South Africa, rapid strides in the settlement of Rhodesia and extension of mining will be witnessed. Fresh reef discoveries are constantly being made; more energy was being shown prior to the war disturbance than perhaps at any time in the history of the country; and capitalists in Europe were showing greater inclination than has been apparent for several years to put up

cash for mining and railway development, when there came the check of progress through the Transvaal trouble. So far, there is nothing phenomenal as to richness; as usual, occasional nuggety specimens, but no especially rich deposits as in West Australia or Colorado; but the outlook is for a steady progress to be made, and in Southern Rhodesia there are possibilities of some properties proving capable of being dealt with by mills of large size. For mining, there are three

RAILWAY BRIDGE OVER THE SHASHI RIVER, THE SOUTHERN BOUNDARY OF MATABELELAND.

essentials—fuel, water, and timber. Hitherto, wood fuel alone has been used, and the timber in vicinity of producing or even developing mines will be exhausted in a short time. Happily the country contains coal deposits—both in the south, near Tuli, and say one hundred and thirty miles north-west of Bulawayo—to both of which points there is the promise of early railway facilities. In winter water is difficult to obtain, and so far very little has been effected in the direction of conservation. In summer there is everywhere superabundance, but it has been permitted to flow away from spruit to stream, and by the numerous rivers into the sea. Judicious expenditure on dams and reservoirs would give abundant supplies for the dry season. The same difficulties were experienced on the Rand and were overcome. Though, as previously observed, the country generally has only small timber, there are large areas of forest land with trees of considerable size—in especial of a tree which is of most useful character, as the white ant —a scourge of the country—will not touch it.

FUNCTIONS AND ORGANIZATION OF THE PURCHASING DEPARTMENT.

By Hugo Diemer.

THE functions of the purchasing department in a manufacturing establishment may be stated as follows:

First:—To secure the most satisfactory material.

Second:—To secure the most desirable delivery of the material.

Third:—To obtain the best terms of payment and lowest prices.

The order in which these functions are mentioned will appear to be, on reflection, the order of their relative importance.

The successful accomplishment of the first function demands that the purchasing agent shall be a man who has a working knowledge of the particular industry for which he is to buy material. If he has, in addition, a knowledge of the fundamental principles of the strength of materials, of metallurgy, and of machine design, so much the better, for he will be able to make practical application of such knowledge.

That the purchasing agent be the possessor of practical manufacturing knowledge is just as essential in an establishment which refers its tests of materials to a testing laboratory, or to its engineering department or superintendent, as in a smaller establishment which does not conduct such tests. If care is exercised to obtain a man of the qualifications indicated, to fill the position of purchasing agent, there will be far less liability to the error, frequently made, of buying material good enough in itself but not exactly adapted to the particular purpose for which it is desired.

It is assumed, at the outset, that persons other than the purchasing agent will have specified the exact physical or chemical properties of the articles that are the most important constituents of the manufactured product of the establishment. But there is no manufacturing process so simple that it does not require the purchase of a great variety of minor articles, the examination of each one of which by the engineering department would be a useless burden. And it is here that the purchasing agent's training and experience come into active play.

To salesmen, the ignorant, affable young clerk who has been promoted to the position of purchasing agent is a familiar type. He is frequently the cause of a salesman's prolonging his stay in a city several days, until finally he sees the man with whom he can have an intelligent conversation. It is quite evident that, where this is the case,

the young man is a hindrance from an economic standpoint, since the additional cost of sales departments on account of prolonged stays is sufficient to increase materially the unnecessary expense connected with the placing of an article on the market.

The securing of the most desirable delivery involves a knowledge of business methods and forms in which, unfortunately, purely technical or shop men have generally had but little training; and this fact is the excuse for the common practice of appointing, as purchasing agents, clerks who have had but little technical or shop knowledge.

A thoroughly systematic conduct of the office, such as is absolutely essential to insure the proper attention to this very important matter of delivery, is much facilitated by the use of certain forms. It is not my present plan to give any set forms, as forms of any kind must be modified to suit the requirements of any particular case. There are some fundamental principles, however, which have stood the test of time in a number of cases, and can well be applied in almost any factory.

It is very customary for foremen to lay the blame for delays in manufacture upon delays in receipt of material. Hence it is of the utmost importance that foremen be compelled to put themselves on record by making requests for material in writing. This provision must form a part of every thorough system designed to provide for the prompt supply of material and supplies.

Where it is at all possible, a shop should be divided into departments, these departments being, for the sake of simplicity, designated as "Section A," "Section B," etc. The foreman in charge of each section should have his requisition book, the requisitions being numbered separately for each section; for instance, those for section "A" should be numbered "A 101," etc., those for section "B," "B 101," etc. For convenience in rapid assorting, the requisition blanks for the respective sections may be printed on paper of different shades of color.

The foreman's requisition is best made in triplicate, one copy going to the store-keeper, and one copy to the purchasing agent. I have frequently heard it offered, as an objection to the introduction of the system mentioned, that a section foreman is too busy to write requisitions. And yet, where this claim was made, I have seen the foreman walk a long distance to the store-room to make a verbal request for supplies, stopping a while to gossip, and perhaps forgetting what he started for; whereas, if his request had been put in the form of a requisition, he would not have had to leave his department, and the request would have been put permanently on record.

It is often a good plan to have the store-keeper determine the quan-

tity of material required, the foreman's requisition calling simply for the article, and the store-keeper filling in the amount. This system of shop requisitions for supplies will be found to be advantageous in securing quicker manufacture, even where there is a "Production" department to provide for ordering the bulk of all material entering into the manufactured product. Where such a production department exists, the shop requisitions will, of course, have a tendency to narrow themselves down to factory supplies and tools. But, in addition, the requisitions will serve as urgent requests for delayed material.

As to the form in which the purchasing agent's order is issued, it is a matter of surprise to me to find that many large establishments are still using the old-fashioned stub-book for orders, necessitating an enormous waste of time in indexing. The indexing is entirely done away with by having purchase-orders typewritten with two additional carbon copies. One set of carbon copies (numbered, of course, consecutively, the same as the original orders), is filed in alphabetical order of the names of the parties from whom goods are ordered, a punch file being used. If a firm has a great many purchase orders, extra-long prongs may be used on the punch file and several different boards may be used, each file-board containing only a part of the alphabet. This method of filing serves the same purpose as an index, and has the enormous advantage of being a system in which the unfilled orders may be kept on file by themselves, something utterly impossible where the old-time stub-book system is used. If desired, an extra set of carbons may be filed according to the consecutive numbers of the purchase-orders; or the original purchase-orders may be copied into an impression copying-book in numerical order. This is usually a superfluous labor, however, as the alphabetical files of completed and uncompleted orders will be found entirely sufficient for reference. As soon as a purchase order has been completed it is taken off the file-board containing uncompleted orders and put onto the file-board containing uncompleted orders, under its proper alphabetical letter, the orders under each letter being arranged according to their numbers. It is well to note dates and amounts of invoices on the orders as they are taken off the incomplete files.

The second carbon copy of the purchase-order (which may be made with a different color of carbon paper—say red or green, to distinguish it from the other copy), is sent to the store-keeper, or to the receiving clerk if he is a separate official, for his guidance on the arrival of material. The shop requisition number should be entered on this carbon copy before it is sent to the receiving clerk. Some shops

attain this same result by having a perforated stub attached to the foreman's requisition, the purchasing agent writing his purchase-order number on this stub and then sending it to the receiving clerk.

A simple method of securing promises of delivery is to enclose a printed post-card acknowledgment of order, with blank for promise of delivery, with each purchase-order where a promise of delivery is desired. To keep track of promises it is very convenient to have a set of thirty-one pigeon holes, each pigeon hole representing a day of the month, and each hole containing memoranda of shipments promised for that day. This affords a systematic method of stirring up delinquent shippers, the number of promises being noted on the memoranda as they are transferred from one pigeon hole to another. Where an establishment is situated in a large city and many orders are local, it is best to separate the city orders from the others so that they can be followed up by telephone instead of by mail. For this purpose it may be well to have a separate series of purchase orders for local use distinguishing them by some convenient prefix letter. A pigeon-hole file as indicated can be run through once a week, on a regular day. It will be found very useful in hastening deliveries of material.

As to the third function of the purchasing department, that of securing good terms and low prices, much depends upon the shrewdness and tact of the purchasing agent. Courteous attention to salesmen is always desirable, and can be accorded without loss of time if nothing but strictly business conversation is indulged in.

The mere request for a little more liberal cash discount than is usually given will frequently result in its being allowed, and the same is true of securing deferred payments where that is desired. The cash-discount system, if applied to all purchases, however small, will result in a considerable annual saving. It is well worth remembering that it is on small purchases that cash discounts are usually allowed.

The card-index system for recording prices has become so generally used that it is hardly worth while to speak of it. I have found, however, that it will be most satisfactory to have two separate price indexes, one for goods actually bought and the other for quotations.

It is very desirable that the purchasing department report daily the cost of all material received and an accurate estimate of the cost of all material ordered, noting approximately the date at which the goods ordered must be paid for.

All of the above systems can be successfully conducted by a purchasing agent with a competent stenographer as assistant, and he will need no other help if his orders do not exceed fifty or sixty a day.

THE FUTURE OF ELECTRICAL SUPPLY.

By Alton D. Adams.

TEAM-DRIVEN electric plants are finding their ultimate development in the service of great areas through sub-stations. Concentration of generating equipment in a single plant has resulted from economies by this means made possible in the items of labor, fuel, water, and transportation. Sub-stations are necessary for purposes of reducing and regulating pressure, supplying diversity of service, and distributing direct current. In the main generating plant are installed the smallest practicable number of large, direct-connected engines and dynamos, which develop alternating current at high pressure. From these high-voltage dynamos, cables are laid direct to the sub-stations, located at short intervals over the service area. The alternating current of high pressure is reduced in voltage, changed to direct current, and delivered to the distribution system by means of transformers, rotary converters, motors, arc dynamos and batteries at the sub-stations. Main stations, generating current at high voltage for delivery to sub-stations, whence it may be distributed at low voltage, were first introduced for the supply of electric lamps and stationary motors, but the system is gradually and surely extending to the operation of electric railways.

Electrical supply was inaugurated some years ago with a station equipment of boiler, steam engine, and dynamo, and, as above noted, the current-generating, transforming, and distributing machinery has increased to three and even four times the rate of energy output. In addition, the length, weight, and cost of transmitting and distributing conductors, per unit of electric supply, has multiplied several times. These great additions to electrical equipment have resulted from the requirements of steam-power generation. The systems of electrical supply take form, in large measure, from the nature of the prime mover on which they ultimately depend. Economy in steam-power production involves the largest practicable production of energy at a single point; this necessitates that service be made to consumers at long distances from the main plant. Supply of electric energy over a considerable distance becomes impracticable, through the cost of conductors, unless comparatively high pressures are employed. Such pressures are not expedient for delivery at the consumers' premises,

or at the motors of electric cars; hence the requirement for sub-stations. For transmission between main and sub-stations, a single kind and pressure of electric current is desirable; for the supply of consumers a variety as to form and pressure of electric energy is necessary. To transform in pressure and convert in quality requires machinery with capacity of two or three times the actually delivered energy. The cost of conductors for transmission between stations is a clear addition to that for local distribution. An ultimate system of electrical supply having been evolved to meet the exigencies of steam driving, it remains to consider whether this system will survive the passing of its prime mover. The answer to this question must turn largely upon the comparative advantages of the electric system and the new motive power.

In the simplest form of electrical supply, the dynamos at the generating station furnish current directly to the distribution system, and there is no transforming equipment between the power plant and the consumer. In such a station, the entire output of the dynamos, save a small loss in distribution lines, is available at the consumers' premises. The investment, therefore, in electrical machinery includes one kilowatt capacity for each kilowatt delivered to distribution lines. In an electrical-supply system of the latest type, for the service of a large area, the output of dynamos or rotary converters at the sub-stations represents the delivery capacity of machine equipment to distribution lines. The energy output of the main electric generators, per unit delivered to local distribution lines, depends on the number and character of the intermediate devices. The simplest common arrangement of the main and sub-station system includes dynamos at the generating plant, and transformers and rotary converters at the sub-stations. A high figure for the efficiency of the rotary converters is 90 per cent., and of the transformers 95 per cent., under average conditions. These figures give a combined efficiency in operation of $90 \times .95 = 85$ per cent., and, allowing a loss of only 5 per cent. in the lines between the main and sub-stations, there will be only $.85 \times .95 = .80$ of a kilowatt delivered to the distribution lines for each kilowatt output at the steam-driven dynamos. Taking the capacity of rotary converters as 1, that of transformers is $1 \div .9 = 1.11$, and of main dynamos $1.11 \div (.95 \times .95) = 1.23$, so that the combined capacity of electrical equipment per kilowatt output is $1 + 1.11 + 1.23 = 3.34$ kilowatts. The main-and-sub-station system of electrical supply, which the conditions of economical steam-power development make necessary for the service of large areas,

requires, therefore, an investment in electrical machinery of more than three times the capacity equivalent to the useful output. It demands, also, expensive transmission cables between stations, while it delivers to distribution lines only about 80 per cent. of the electrical energy developed. This is about the best showing that can be made for the ultimate electric system with steam drive. In many sub-stations, a part of the energy sent out is derived from the main supply by the use of transformers, motors, and dynamos, thus further increasing the cost of equipment and lowering the total efficiency below the point just stated. Storage batteries play an important part, as to pressure regulation and maximum-load capacity, in sub-stations and in many generating plants where dynamos are connected directly to distribution lines. As the action of batteries has no important bearing on the questions here considered, however, figures concerning them are omitted. So long as the steam engine continues to be the best available prime mover, the main-and-sub-station system of electrical supply over large areas, for light, power, and street-railway service, seems to offer the best possible solution.

Another form of prime mover has, however, for years been growing in importance, now rivals the steam engine, and may in the future largely displace it, by reason of superior economy in fuel. This new motive power is the gas engine. Recent developments in gas-engine practice and in the production of fuel gas have demonstrated an efficiency for the combined producer and engine, in brake horse-power hours per pound of coal consumed, which is much better than the best performance of the steam boiler and engine. In a small plant containing a gas producer and two engines, each under 100 horse-power in capacity, tests have shown the consumption of anthracite buckwheat coal to be only 1.03 lbs. per i.h.p. hour. About the best figures that can be obtained for the consumption of a more expensive grade of coal, in large steam plants with compound condensing engines, are 1.5 lbs. per i.h.p. hour, or 50 per cent. more fuel than was required in a gas-engine test. The figures just noted for fuel consumption with gas engines are by no means isolated ones, similar results having been obtained in many cases. On large gas engines a higher rate of power production per hour has been obtained per unit of fuel, as in one case of a 320-h.p. engine, where an indicated horse-power was produced with a consumption of .81 lb. and a brake horse-power on 1.03 lbs. of coal per hour. A reduction of one-third of the fuel now consumed in the best steam-power plants certainly furnishes a large inducement to substitute gas engines,

and there seems to be no corresponding disadvantage to offset the higher economy. The first cost of gas engines is not far from that of compound steam engines with condensers, and feed-water heaters, high-class boilers, and attachments cost but little less per unit than do fuel-gas producers. The requirements of the gas-engine-and-producer plant are not more exacting as to fuel transportation and water than in an equivalent steam-power station, and the labor item for the same output is no larger. There is good reason to think, therefore, that the steam engine, having reached the maximum efficiency of which it is capable, through its range of temperature, will gradually be displaced by the gas engine.

The electrical-supply system for a great area, including one generating station and many sub-stations, will certainly be at an advantage over its present condition when equipped with gas producers and engines requiring only about two-thirds of the coal now consumed under the steam boilers. The large investment and losses in electrical lines and machinery remain, however, as before, and it remains to discover whether these items can be reduced. Evidently, the additional electrical equipment of the main-and-sub-station system, beyond that of the old arrangement with several generating plants, can only be eliminated by replacing transformers, electric motors, and rotary converters with prime movers and dynamos at the sub-stations. This does away, of course, with the single, large, power stations, and is, to a large extent, a return to earlier practice. The system with a number of small generating plants is known to be uneconomical, when steam is the motive power, but the gas-engine equipment may be able to meet the conditions. It would be possible to equip a number of comparatively small gas-producer-and-engine plants, over a large area of electric service, and operate them at a greater economy, as to fuel consumption, than can be attained in the best steam-driven station of any size whatsoever. The room required for these small producer-and-engine plants, the costs of water and of fuel transportation, also that of extra labor, would render them decidedly inferior to a single large gas-producer and electric-generating station distributing to sub-stations on the present plan. The conclusion seems certain that the gas-generator plant, like the steam plant, is at a great advantage in point of economy when conducted on a very large scale, at a single point.

There remains but one other alternative to be considered; since the gas should all be generated at a single point, is there any decided advantage to be gained by its distribution to sub-stations through pipes

and its use at these sub-stations in engines driving dynamos which supply lines direct? Such an arrangement will dispense entirely with transmission cables between main and sub-stations, will reduce the complete capacity of electrical machinery to its actual delivery into distribution lines, or to less than one-third of that required in the system of main and sub-stations, and will lower somewhat the total gas-engine capacity, by avoiding the transmission and the transforming losses. Allowing the dynamos in sub-stations an efficiency of 90 per cent., the energy developed by the gas engines is only 1.11 times that delivered to distribution lines, instead of 1.23 times as in the main-and-sub-station system. As no labor for the operation of engines is now required at the plant where the gas is generated, and as the operation of engines at the sub-stations will take little more attention than did that of the electrical machinery there displaced, the labor item may be considered constant. Sub-stations with gas engines and dynamos occupy little, if any, more space than with the present electrical equipment. Water for cooling gas-engine cylinders must be provided at sub-stations, but the automatic devices now available to cool water make it possible to reduce the supply to the amount lost by evaporation. The only additional item of equipment necessary in a system with sub-stations operated by engines, supplied with gas from a single generator plant, is that of pipes to convey the gas. Radiating from the gas producer of such a system there might well be, for an average case, from ten to twenty large gas mains, laid directly to the several sub-stations. Each of these gas mains should, of course, be large enough to supply its sub-station at periods of maximum load. To compare the investment for a system of electrical supply, in which current generated at a main station is transmitted to the sub-stations by insulated cables, with a system in which gas from a producer plant is piped to engines at the sub-stations, only the items peculiar to each method need be considered.

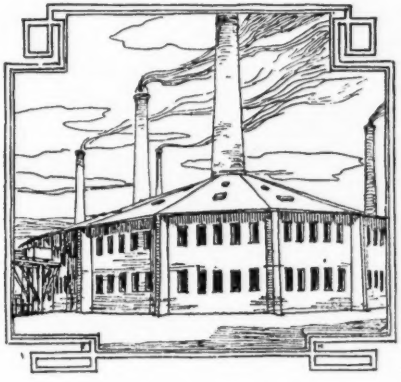
Though the system with electrical transmission between main and sub-stations includes greater losses from gas engines to supply lines than does the system where the gas itself is transmitted, the smaller engines needed for sub-stations may cost a little more per unit, so the total engine investment may be considered constant, whether at the main or sub-stations. Rotary converters at the sub-stations cost somewhat more than dynamos of the same output to replace them, but, yielding a little to the complete electric equipment, the first outlay may here again be held to be equal. Assuming that only transformers and rotary converters are necessary at sub-stations, though motors and

dynamos are in some cases required, the excess in electrical machinery, in the case of the system with main power-generating plant and insulated transmission-cables to sub-stations, includes the main dynamos and the transformers. The transmission cable is peculiar to the complete electric system, the gas mains to the plan with gas engines at sub-stations. In either case the distribution conductors should be the same, and the use of batteries at sub-stations remain constant. The investment in main dynamos, transformers, and transmission cables on the one hand should, therefore, be set against that of the gas mains on the other.

A comparison of these items can best be made from the conditions of a specific case. As the sub-stations each present the same problem, differing mainly as to distance and capacity, a consideration of one will be sufficient. A practical size of sub-station may be selected from present practice at 300 kilowatts or 400 h.p. capacity, and a practical distance of five miles from the electric-generating or the gas-producing plant may be assumed. As above shown, the main dynamos in the electric-transmission and distribution system must have a capacity for 1.23 times the rate of delivery by the rotary converters, so that a supply of 400 h.p. to distribution lines at the sub-station, batteries not being considered, requires dynamos at the generating plant of $400 \times 1.23 = 492$ h.p. capacity. The output of transformers at the sub-station, as above shown, will be $400 \times 1.11 = 444$ h.p. Allowing an installed price of $25 per h.p. for the main dynamos and $10 per h.p. for the transformers, their combined cost for the delivery of 400 h.p. by the rotary converters is $(492 \times 25) + (444 \times 10) = \$16{,}744$, or $\$16{,}744 \div 400 = \$41.83$ per delivery capacity to distribution lines. A pressure of 6,600 volts has been adopted in several important instances for the dynamos at a main generating plant supplying a number of distant sub-stations, and may fairly be taken for this case. To transmit 492 h.p. a distance of five miles, in the form of electric current at 6,600 volts, and at a loss of 5 per cent., requires an outlay for insulated cable and tile conduit of approximately $10,000, exclusive of laying, or $\$10{,}000 \div 400 = \$25$ per h.p. delivery capacity to distribution lines. The total outlay for machinery and cables peculiar to the all-electric system is, therefore, the sum of $\$41.83 + \$25 = \$66.83$ per h.p. delivery capacity to rotary converters at sub-stations. With dynamos having an efficiency of 90 per cent., driven by gas engines at sub-stations and delivering 400 electrical h.p. to distribution lines, the engine must develop $400 \div .9 = 444$ h.p. Allowing 100 cu. ft. of producer gas for engine consumption per brake-horse-power hour, the

rate of gas supply must be $444 \times 100 = 44{,}400$ cu. ft. per hour during periods of maximum load, provided that no considerable storage capacity is provided at sub-stations. The cost of a pipe five miles long to deliver gas at the rate just named, with a friction loss of 5 per cent. of the power produced by the gas, is about $26,400, or $26,400 $\div$ 400 = $66 per electrical h.p. delivered for distribution. This item for pipe does not include the cost of laying, which may be left to offset the cost of laying the electric cable and conduit, not computed in the other case. This large charge for pipe would be very much reduced with a gas of high heating capacity, like that used for illumination, of which only about one-fifth the bulk would be required to yield the same energy.

Comparing the two systems of electrical supply above described, it seems that the first cost of the complete equipment is about the same for each case, but the complete electric system is somewhat less efficient. The combined efficiency of the main dynamos, step-down transformers, transmission line, and rotary converters is $.90 \times .95 \times .95 \times .90 = .73$, while the combined efficiency of the gas main and the dynamos at the sub-station is $.95 \times .90 = .85$. The system which places the gas-engines at sub-stations, while costing no more for the first investment, delivers $.85 \div .73 = 1.16$ times as much of their output for distribution as does the system with all the engines at a main station.



STEAM-ENGINE BUILDING IN SWITZERLAND.

By A. Stodola.

HE who travels through Switzerland, although but a tourist, admiring the marvellous beauties of its natural scenery as a layman in mechanical matters, must perceive the abundant sources of water power everywhere available. The numerous hydraulic-power plants, situated upon the principal rivers at points where streams pour down from the mountain clefts, bear silent witness of the direction in which the efforts of Swiss engineers have been principally employed. When the traveller discovers further that Switzerland possesses almost no iron, and no coal at all, he will be doubly astonished to learn that this land holds a pre-eminent position in the art of steam-engine construction, in the building of machines whose very existence depends upon the possession and use of coal.

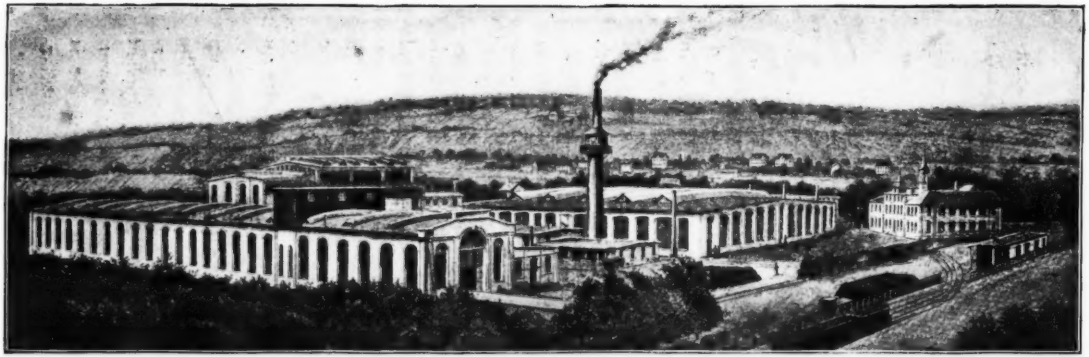
Switzerland itself, however, is no insignificant user of steam power, when its small area is taken into consideration. Already the rapid growth of its manufacturing and transportation industries is outstripping its water-power facilities. In the late 70's the city of Zürich erected what was at that time considered a very large hydraulic plant, intended to supply power for manufacturing at low cost. Since then the increase in population has been so rapid that an auxiliary steam plant of 3,000-h.p. capacity has been found necessary to supply the immediate demands for light, power, and water-supply; while the original plans for the development of a special industrial quarter, served with power by wire-rope transmission from the hydraulic-power plant, have proven altogether inadequate.

The city of Winterthur, with all its important metal-working industries, uses only steam power, and the same is true of Basle, where the great chemical color works are situated; for the immediate future

The last few years have been marked by an amazing advance in the range and in the total of power applications—an advance of which the most striking feature has been the constant interplay and mutual reaction of increased use and improved economy. The tendency everywhere has been toward rapid growth in the size of prime-mover units, and recent events have made international comparisons of practice very valuable.

Prof. Stodola's clear and able review is founded upon his intimate acquaintance with the Swiss industry—practical construction as well as theory and design. It was prepared by special request for THE ENGINEERING MAGAZINE, and is here presented in translation from the original German. Owing to lack of time, the translation has not had the benefit of the author's revision.

It will be of particular interest in connection with Mr. C. A. Hague's contribution on "The Steam Engine for the Electric-Traction Power House," published in this Magazine, December, 1899, and January, 1900, and with the forthcoming papers by Prof. Gutermuth, on German steam-engine building, and by Mr. Philip Dawson, on the contrast between English and American steam-engineering practice.—THE EDITORS.



TWO GREAT STEAM-ENGINE BUILDING WORKS OF SWITZERLAND.

The upper cut shows the establishment of Escher, Wyss & Co., Zürich, the lower the machine-shops and foundry of Gebrüder Sulzer, Winterthur.

it is evident that nearly all industries must look to steam as the most available source of motive power.

According to the report of the Swiss Steam-boiler Users' Association, the number and distribution of steam boilers at the close of 1898 was as follows:

Industry.	No. of Boilers.	Heating Surface.
Textile Industries	1,054	443,150 sq. ft.
Food Supplies	663	162,514 "
Chemical Industries	183	83,635 "
Metal Industries	373	115,700 "
Woodworking	353	79,146 "
Paper Mills	126	59,222 "
Steamboats	172	108,200 "
Water Works and Electric Plants	52	30,968 "
Special and Miscellaneous Industries	935	247,236 "
Totals	3,911	1,329,771 sq. ft.

These figures will enable a general idea of the steam-power in Switzerland to be obtained, it being understood that the boilers of the steam railways are not included in the above table. The growth of steam plants in the future, however, must be expected to be much more rapid, since the new factor of competition with electric transmission must be considered. It is well known that since the famous transmission of electric power from Lauffen to Frankfort was accomplished, electric-transmission plants have become extensive in Switzerland. Electrochemistry has appeared as a great user of power, demanding constantly increasing investments of capital for the construction of great electric-power stations, supplying many chemical works with energy. Examples of projects now under consideration are found in the scheme to take 20,000 h.p. from the Rhine for use in the Canton of Zürich, and in the plan to obtain 60,000 h.p. from the valley of the Etzel for distribution to large and small consumers. A continuance or a possible increase in the price of coal, otherwise an actual calamity, will doubtless cause these projects to be put into immediate execution, and so we may soon see Switzerland divided up into centres of power, distributing the energy of the streams to the neighbouring country. Some provision must be made for the intermediate spaces which must remain between the areas thus supplied with power, and this doubtless will be by the use of steam power. Another factor in the further introduction of the steam engine is found in the limitations which have made themselves felt in the utilisation of hydraulic power. In many instances it has proved necessary to provide a large reserve steam plant for use in case of insufficiency of the water-power, when such a reserve was not at all considered in the

original design. If the very large dimensions required for hydraulic motors for low heads be considered, and the later experience in the effects of climatic changes be consulted, the former estimates of the cost of hydraulic power may have to be materially revised.

The last factor with which the steam engine has to contend in its struggle for existence is the use of the gas engine as a prime mover, especially in the use of Dowson or producer gas. The enthusiastic efforts of many advocates of this system, however, have somewhat abated since it has been demonstrated that in the great majority of cases only coke or anthracite coal can be used in such gas-producers, and the predictions that lignite and inferior coals could be advantageously used still remain unfulfilled. The inability of the gas engine to stand temporary forcing above its ordinary capacity is a defect in this class of motors, while a slight falling-off in the quality of the gas makes a marked difference in the efficiency. In several instances of gas-engine plants for operating electric tramways, the capacity has been underestimated some 10 to 20 per cent., requiring enlargement to be made at much inconvenience, the reserve motors being compulsorily operated continuously while the stations were being enlarged. Nevertheless, Dowson generator plants are very numerous in Switzerland, and in Baden, Zürich, Oerlikon, Lausanne, Romanshorn, Berne, Uster, and St. Gall there are gas-power plants for lighting or for tramway driving, in addition to a large number of private installations. The most important plant is at Basle, where more than 1,000 h.p. are generated by means of Dowson gas. The popularity of this process is due to the general use of anthracite coal in Switzerland. The great distance of the coal districts, and consequent high transport charges, render it desirable to use the best quality in the most economical manner, and this has led to an extensive introduction of Belgian anthracite. The cost of coal and its increasing price will be appreciated when it is understood that the best coal from the Saar and Ruhr Districts cost 320 to 350 francs per car of 10,000 kilogrammes a year ago, while at the end of December, 1899, the price had risen to 450 to 480 francs, the latter price corresponding to about $9.40, or 39s., per long ton.

All these conditions indicate that the building of steam engines in Switzerland will no longer remain what it has mainly been up to the present time—an export industry. In such case, however, its characteristic position will in no wise suffer and the industry, skill, and intelligence devoted to it will doubtless raise it to a position still higher than that which it occupies at the present time.

The cost of engine building in Switzerland is affected not only by the high cost of shipment of the completed work, but also by the fact that nearly all the principal raw materials, especially coal and iron, must be imported from other countries. Wage conditions, also, are certainly not more favourable than those existing in the works of her great competing neighbour, Germany. The Swiss workmen stand as high in respect to their standard of living and home comforts, as any of their fellow workmen on the Continent or in England; I can make no comparisons with conditions in America. The dwellings of the Swiss workmen are certainly a degree better than those of the same class in other countries, and all the conditions of life have been strongly influenced for the better by the constant stream of foreign travel, due to the natural attractions which have made Switzerland a terminal for travellers from all countries furnishing examples which have reacted upon the standard of comfort of the whole population. It is only necessary to point to the great institutions for the sick (hospitals), and to the united beneficial and accident associations; which associations in the near future will probably acquire such a legal status as may materially affect industrial conditions.

Under conditions already so difficult and constantly growing more difficult, the establishment of Gebrüder Sulzer, of Winterthur, was founded in the year 1834 by the brothers Johann Jakob and Salomon Sulzer. They were the pioneer steam-engine works of Switzerland, destined to become famous throughout the entire world and to exert a powerful influence over Swiss engine-building. Beginning with a small iron foundry and machine shop at Winterthur, they at first employed only twelve men. From this small beginning grew the present great establishment, which, with the branch establishment at Ludwigshafen, in Germany (founded in 1881) employs more than four thousand workmen, and has constructed more than four thousand two hundred steam engines, aggregating over half-a-million horse power. It is an interesting fact that the grandfather of these two brothers, in the latter part of the 18th century, conducted the business of a metal founder, and that his numerous descendants still follow either the industrial or commercial side of the same business.

The special feature of the work of the firm of Gebrüder Sulzer is found in the wide scope of technical effort early undertaken and fully developed to an extent productive of remarkable consequences. In the year 1866, when the fame of Corliss first began to be known in Europe, Gebrüder Sulzer commenced the manufacture of the poppet-valve engine which they have since brought to such a high degree of

perfection. The tubular double-seated valve had, indeed, been known before this time, but had not been considered capable of competing with the Corliss valve. Since that time, however, the name of Sulzer has been identified with the development of the steam engine in Eu-

FIG. 1. TRIPLE-EXPANSION ENGINE WITH TWO LOW-PRESSURE CYLINDERS.
Normal capacity, 1,800 h. p. Built by Gebrüder Sulzer, of Winterthur, Switzerland, and installed at the Nikolski Manufaktur Savva Morosoff's Son & Co., Moscow, Russia.

rope much in the same manner as that of Corliss is known in America. The relative advantages of the poppet and Corliss valves have been discussed so often that it is not necessary to go into that part of the subject here. The claim of both types as to correctness of action and durability have been fully demonstrated for many years past by the successful increase in speeds and reduction in steam consumption in a great number of installations, and by the successful application of superheated steam. As a consequence of the increased number of revolutions and greater steam pressures demanded by modern practice, the double-seated valve has, in some instances, been replaced by a four-seated one. This is accomplished by the combination of two double-seated tubular valves, one above the other, the dimensions depending upon the quantity of steam flowing through them. By this arrangement the lift of the valve need be only one-half that otherwise required, thus also diminishing the drop to the same extent, and reducing the weight of the moving mass and lessening the strains upon the levers. The introduction of the four-seated valve is the latest con-

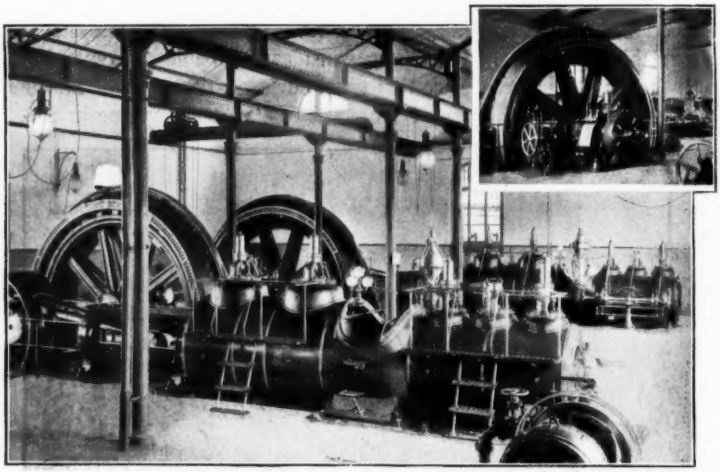


FIG. 2. HORIZONTAL COMPOUND ENGINE, ZÜRICH, SWITZERLAND.

Built by Gebrüder Sulzer, Winterthur, and peculiar in having the low-pressure cylinder nearest the crank-shaft. Normal capacity 1,000 h.p.

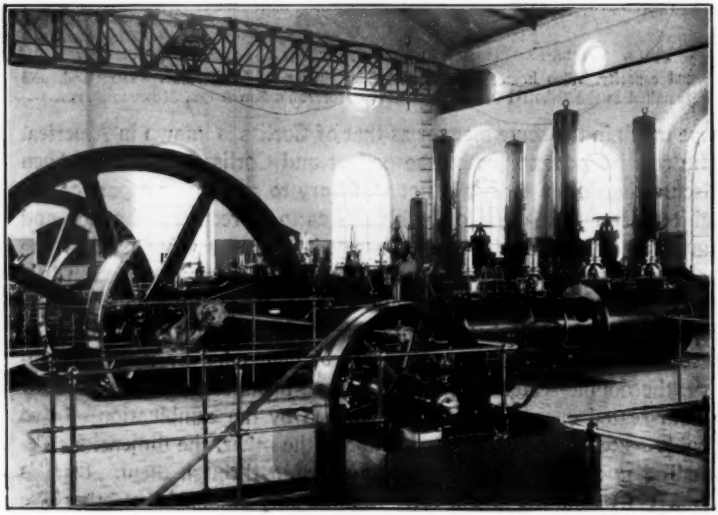


FIG. 3. TRIPLE-EXPANSION PUMPING ENGINES AT ST. GALLEN, SWITZERLAND.

Built by Gebrüder Sulzer, Winterthur; pumping against a head of 1,082 feet. This engine showed under test, a thermal efficiency of 12 per cent.

tribution of Gebrüder Sulzer to the development of the steam engine. So far as the use of superheated steam is concerned, the poppet valve is well adapted to the peculiar conditions, on account of the greater durability over the Corliss valve, as well as over the piston and the

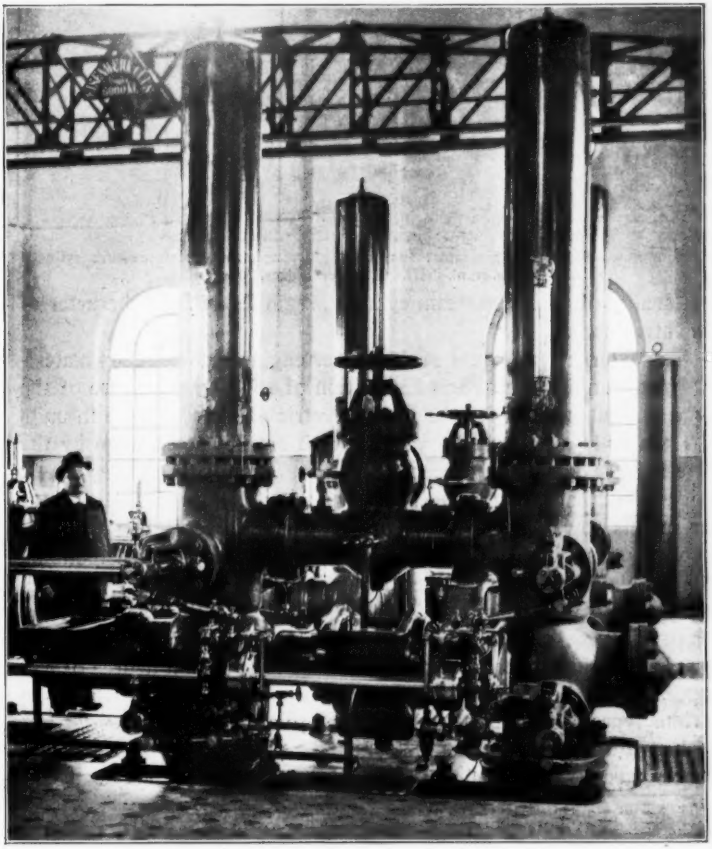


FIG. 4. PUMP END OF THE ST. GALLEN PUMPING ENGINE.

A portion of the engine shown in Fig. 3. The pump is operated by a prolongation of the low-pressure piston rod. Gebrüder Sulzer, Winterthur.

plain slide valve, there being little friction and no necessity for the use of a large quantity of high-grade lubricant. Still, it must be admitted that the use of highly superheated steam requires the use of the

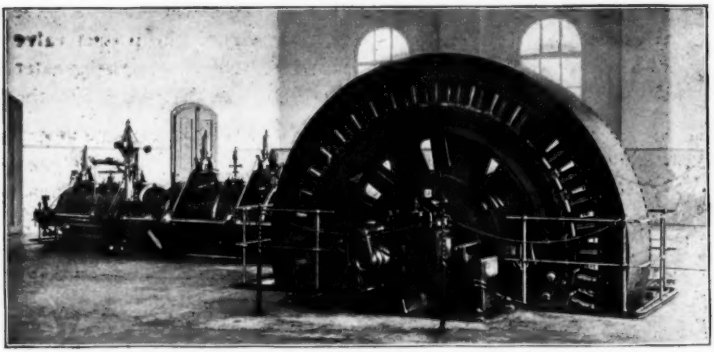


FIG. 5. TANDEM-COMPOUND HORIZONTAL ENGINE.
Direct-connected to electric generator; showing the arrangement of low-pressure cylinder nearest the crank-shaft. Gebrüder Sulzer, Winterthur.

best quality of oil in the steam cylinder, regardless of the character of the valves used.

The external valve gear of the Sulzer engines has not been materially modified since the Paris Exposition of 1878. In the case of the large vertical engines for the Berlin electric plant, which are in units of 1,500 and 3,000 h.p., the valves which are not acted upon by the governor are operated by eccentrics in connection with rocking levers. It is evident that heavy valves may be operated in a much quieter manner in this way, and brought more gradually to rest, than with the revolving cams with their more exact drop and accelerated motion.* The regulation is usually effected by the Porter governor, with its heavy pear-shaped weight and oil dash-pot, but in this case the Hartung spring governor is applied.

The external appearance of the engines is of a high degree of elegance, as will be seen by reference to the illustrations, in which the various types of engines already referred to are shown.

Fig. 1 shows a horizontal triple-expansion engine of 1,800 h.p. normal capacity, an arrangement which has been found very satisfac-

* For a description of these engines see *Zeitschrift des Vereines deutscher Ingenieure*, 1899, page 1349. Vertical engines now represent the highest development of steam-engine construction in Europe, being used whenever the conditions are favourable—as in the case of the Berlin station, where a continuous current of moderate pressure was to be generated in an important structure in the midst of the city. The smaller engines have a speed of 100 to 107 revolutions per minute, the larger ones 85 revolutions, the former being two-cylinder compound engines, the latter triple-expansion with four cylinders, with double crank shaft, the high-pressure cylinder and one low-pressure cylinder acting upon one crank, and the intermediate and second low-pressure cylinders acting upon the other.

Especial provisions were made to permit the use of highly superheated steam, a degree of superheat of more than 300 degrees C. being employed; for further details the reader is referred to the above cited journal.

tory for large engines. In this case there are two low-pressure cylinders, the arrangement being, on one side the high pressure cylinder and one low-pressure cylinder, and on the other the intermediate and the other low-pressure cylinder, each side being tandem, the shaft having a crank on each side of the driving wheel.

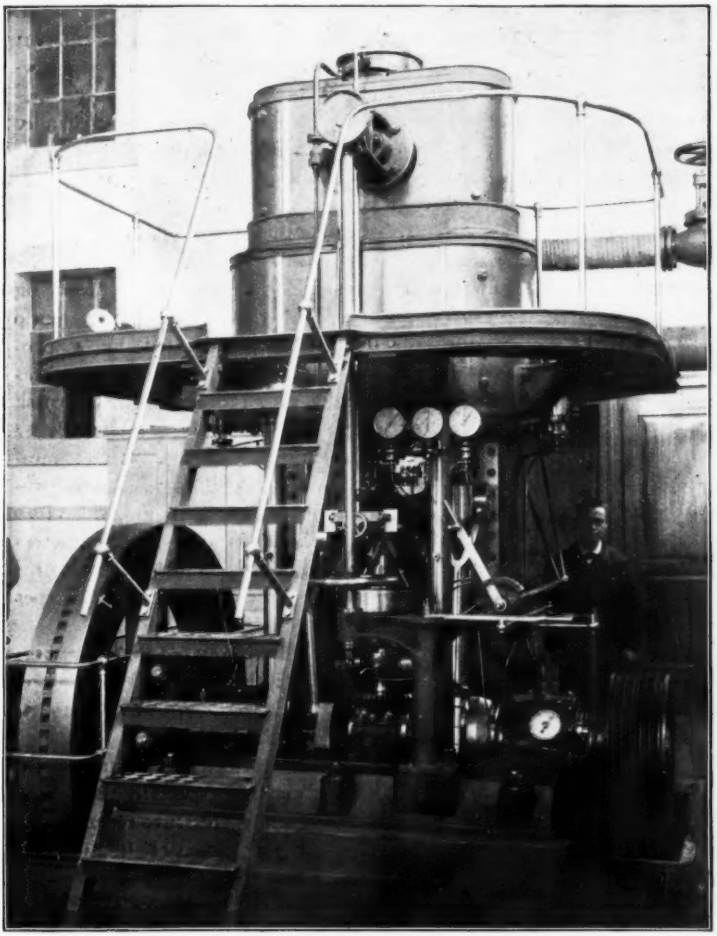


FIG. 6. HIGH-SPEED DOUBLE-CYLINDER VERTICAL ENGINE.

With rotating piston valve, driven directly from governor shaft. Gebrüder Sulzer, Winterthur.

Fig. 2 shows an engine of the horizontal tandem-compound type, being that of the 1,000-h.p. steam-dynamo in the municipal electric plant at Zürich, the most noteworthy feature being the arrangement of the large cylinder by which the steam from the receiver passes through the jacket of the low-pressure cylinder, the latter thus being maintained at a lower temperature than the high-pressure cylinder. The stuffing boxes of the two cylinders are also placed further apart than is usual in engines of this style, and the connection from the low-pressure rod to the crank shaft appears to be a more natural arrangement than the ordinary plan of placing the high-pressure cylinder nearest the shaft. This arrangement is typical of a number of Continental electric plants, having been first employed by Messrs. Sulzer for the plant at Frankfurt.

In Figures 3 and 4 are shown the steam pumps of the water works of the city of St. Gallen. In these engines the high-pressure and intermediate-pressure cylinders are placed on one side, the low-pressure cylinder and the double-acting pump being on the other side, the pump being operated by a prolongation of the low-pressure piston rod. The pump operates at 60 revolutions per minute and delivers 2,150 litres (473 British gallons) against a head of 330 metres (1,082 feet). Tests made by the author upon this engine showed an efficiency of 51 to 52 kilogrammetres (369 to 376 foot-pounds) of water raised for 1 calorie produced by the fuel (coke), corresponding to a thermal efficiency of 12 per cent., the developed energy being about 360,000 kilogrammetres (2,603,880 foot-pounds) per kilogramme (2.2 pounds) of coke of a calorific value of 7,000 calories per kilogramme, (12,627 B.T.U. per pound).*

This remarkable result, which can only be compared to a few cases in American water-works practice, is due to the superior construction of this comparatively small triple-expansion engine, and to the use of an economiser in connection with the steam boilers.

Figure 5 illustrates a tandem-compound engine, similar in construction to that shown in Fig. 2, and exhibiting especially the direct-connected alternating dynamo. In this case the armature remains stationary, the revolving field magnets forming a portion of the fly-wheel rim, connected by many arms to the hub.

In Fig. 6 is shown a remarkable vertical engine of small size, constructed by Gebrüder Sulzer, and characterised by the employment of

* For details of this trial see the report in *Zeitschrift des Vereines deutscher Ingenieure*, 1898, page 197.

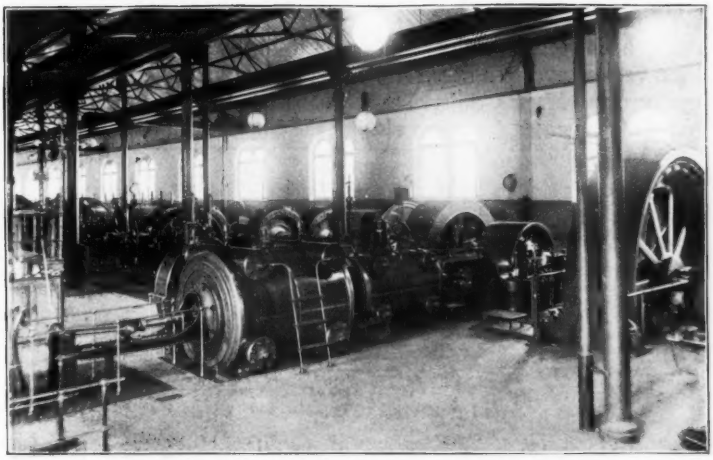


FIG. 7. HORIZONTAL TANDEM-COMPOUND ENGINE.

Frikart-Corliss valve gear with positive connection to shaft governor. Installed at Zürich Electric Station. Escher, Wyss & Co., Zürich.

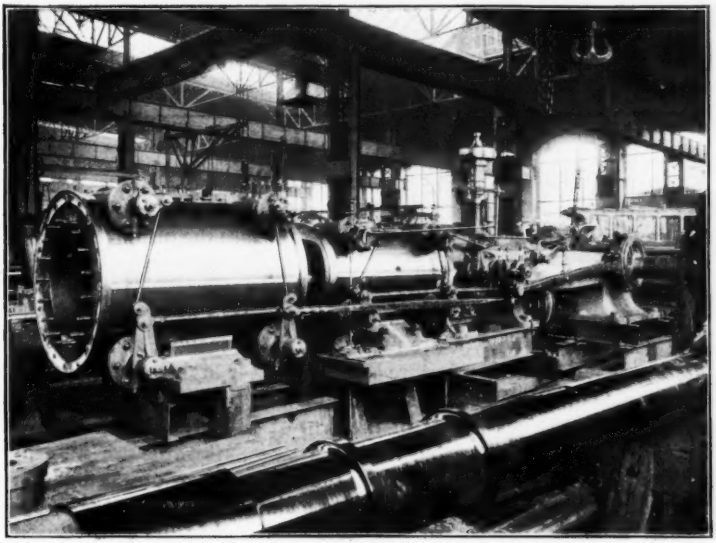


FIG. 8. TANDEM-COMPOUND ENGINE IN ERECTING SHOP.

Showing especially the simplified Frikart-Corliss valve gear, as constructed by Escher, Wyss & Co., Zürich.

rotary, hollow-piston valves. It is well known that reciprocating piston valves have been successfully operated without the use of packing rings, and Messrs. Sulzer have demonstrated that the rotary valve can also be operated for years without the employment of rings. The

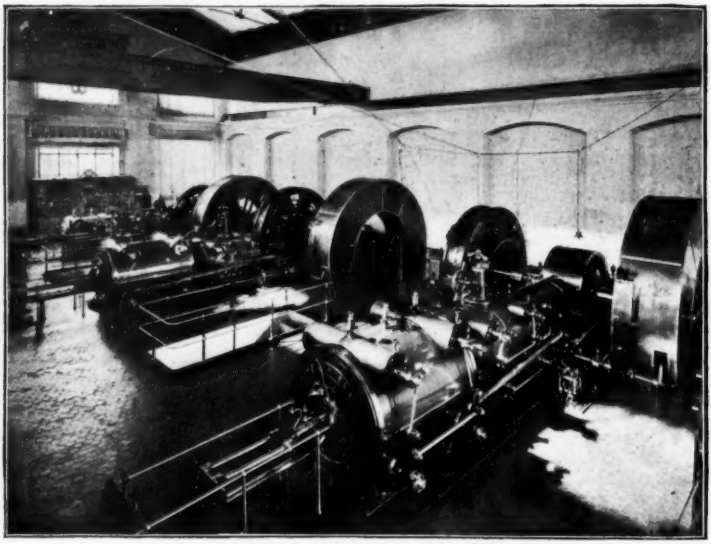


FIG. 9. TANDEM-COMPOUND CORLISS ENGINES.
Installed at the Central Electric Station, Florence, Italy. Showing the improved Frikart valve gear. Escher, Wyss & Co., Zürich.

valves are operated by the same shaft which drives the governor, so that the only reciprocating parts of the engine are the pistons and connecting rods. This type of engine is especially adapted for high rotative speeds and is suitable to the same kind of service as engines of the Willans type, also possessing the added advantage of variable expansion. Engines of this type are made tandem-compound, and all styles possess the double-acting feature so desirable for high rotative speeds.

The second notable establishment in Switzerland for the construction of steam engines is that of the firm of Escher, Wyss & Co., of Zürich. This firm was established in the early part of the present century and was originally devoted to the manufacture of turbines, in which department of engineering it has maintained a leading position. Escher, Wyss & Co. very early became interested in the construction of marine engines, and have furnished the machinery for a large number of the steamboats for many of the lakes of Europe, as well as for river steamers on the Rhine, Danube, and other streams.

More recently this firm has undertaken the building of Corliss engines, using the Frikart modification of the Corliss valve gear, or the Frikart shaft-governor, acting upon the admission valves. This form of valve gear became well known to engineers by the exhibit made by Messrs. Escher, Wyss & Co. at the Paris Exposition of 1889. Since then a number of modifications have been made by them, especially in the simplification of the gear and the elimination of many parts. The admission valves are now operated by toggle-lever connections, carried upon the spindles of the exhaust valves, the construction being clearly shown in Fig. 9. A number of other simplifications have been made in the valve gear, as will be seen in Fig. 8, which represents a tandem-compound engine in course of erection.

The arrangement of shaft governor is especially well adapted for high rotative speeds, as is seen in Fig. 7, which shows a 750-h. p. en-

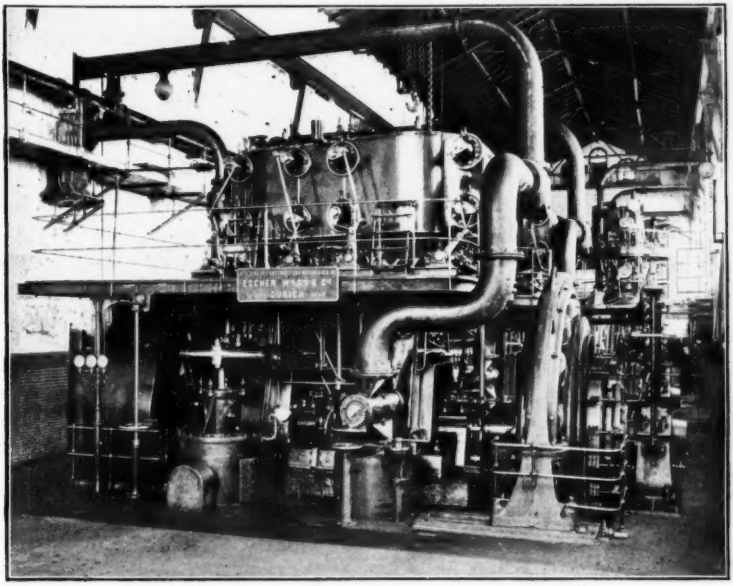


FIG. 10. DIRECT-CONNECTED VERTICAL COMPOUND ENGINES.
Corliss valve gear with positive connection to shaft governor. Escher, Wyss & Co., Zürich.

gine in the Zürich electric station operating at a normal speed of 100 revolutions per minute. The aim of this firm is to advocate somewhat higher rotative speeds than have hitherto been considered normal in Europe, without encouraging the use of dangerously high speeds.

Vertical engines with shaft governors are shown in Figure 10, which represents the 800-h. p. engines in the Madrilena electric station. Escher, Wyss & Co. also build a very well-designed line of vertical engines using the Rider slide-valve gear, controlled by a very ingenious and powerful spring governor of their own design. Fig. 11 shows an installation of these engines at the St. Petersburg electric station, while Fig. 12 enables the construction of the engine to be more closely examined.

The construction of locomotives is a subject which falls somewhat outside the scope of this article. The Swiss Locomotive Works at Winterthur has for many years supplied the demands of the country alone, and in consequence of the many steep inclines of the Swiss railways, such, for example, as those of the St. Gotthard railway, has been called upon to solve many difficult problems in locomotive building.

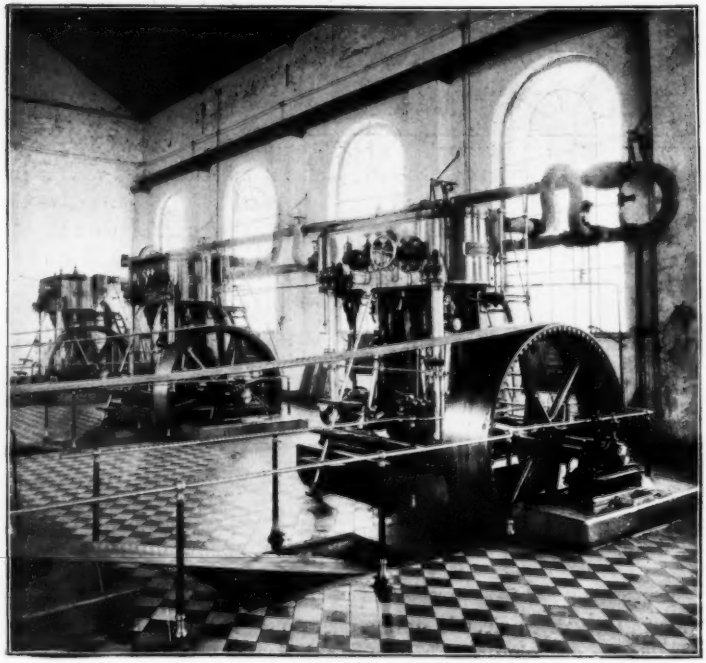


FIG. 11. VERTICAL COMPOUND ENGINES.
With Rider automatic slide-valve cut-off, as installed at the St. Petersburg Electric Station. Escher, Wyss & Co., Zürich.

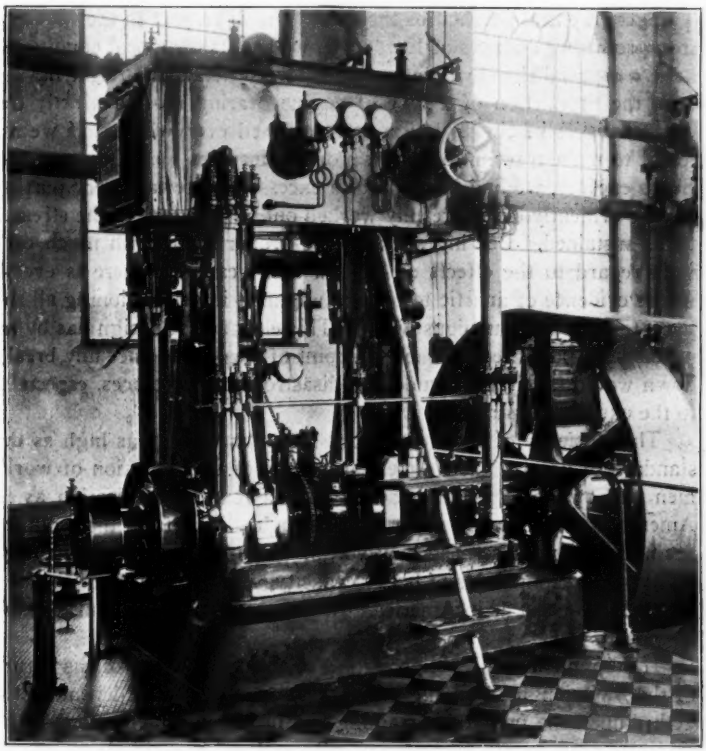


FIG. 12. ENGINE AT ST. PETERSBURG ELECTRIC STATION.

A nearer view of one of the vertical engines shown in Fig. 11, showing the Rider valve-gear and governor.

The Burckhardt Machine Works at Basle is devoted especially to the construction of air compressors, and has acquired a well-deserved reputation in connection with the construction of machinery for chemical works. The firm of E. Mertz, also at Basle, has built some excellent high-speed single-acting engines from the ingenious designs of the well known engineer, Mr. C. E. Brown, a number of these having been selected for use in the navies of foreign countries.

In this brief glance which we have taken over the steam-engine industry of Switzerland we have found little which is really new, the principal characteristic of the industry being intense activity in the development of the best points of systems already known elsewhere.

The geographical position of the country with respect to the coal and iron-producing districts of Europe, as well as its own local conditions, have compelled the closest attention to every detail, the result having been the production of a type of engine bearing most distinctly the characteristics of Swiss design as recognised everywhere. If we attempt to make a technical analysis of the features which characterise Swiss engines, we find in no part an excess of material, every portion having evidently been carefully worked out with regard to the stresses to be sustained. Bearing surfaces are proportioned with much care with regard to the effects of friction and wear, and there is everywhere evidence of artistic taste and judgment in proportioning all the parts to form a harmonious whole. This elegance of design has by no means been permitted to reach the point of weakness, since any breakdown would surely be attended by disastrous consequences, especially to the export industry.

The efficiency of the Swiss workshops stands fully as high as the standard of design. The American system of specialisation of workmen and of tools has not reached such a marked application as in America itself, although many tools brought direct from that country are in use. In one respect, however, progress has been made, namely, the use of machine tools of heavy capacity, driven to a rate of production fully as great as in America. In this respect an important change is evident.

If an opinion may be expressed as to the probabilities of the future of the Swiss engine-building industry, it must be that it depends altogether upon the favourable training and increasing intelligence of the Swiss workman, which, if rightly directed, without hindrance from labour organisations, must control the turn of the balance.

Upon this point the future development of the Swiss mechanical industry must depend, as it has in the past. If the great organisations fully grasp this fact, and are found to be in the hands of capitalists and managers who are above a mistaken parsimony, we may hope to see results which shall still be worthy of the past reputation of the country.

THE POLICY OF SECRETIVENESS IN INDUSTRIAL WORKS.

By A. E. Outerbridge, Jr.

IT is interesting to trace the gradual development of types in nature and to note their persistency when developed. This principle of persistency applies to national characteristics as well as to the organic world. Thus peoples whose boundaries adjoin and whose intercourse is frequent retain their prominent characteristics, habits of thought, and methods of work where mutual assimilation might be expected. Gradual modifications of types, however, do occur in nature owing to various causes, such as climatic variations or changes in environment. This differentiation is noticeable in offshoots of the same race and language, for instance, the English and the Americans. The tendency has been for the latter to strike out in independent lines, developing new types of thought and methods of work, while the former seem to persist in the motto *State super vias antiquas.* This racial distinction was forcibly shown in an able paper—one of a series—upon "American Competition," now appearing in the London *Engineering,* written by Mr. George Howell, F. S. S., who says: "Then it must be admitted that 'we Britishers' have our prejudices, and so strong are they very often that we stubbornly stick to old methods when newer and better ones have been discovered." In how many ways does this impress a progressive American who for the first time visits England, its colleges, its workshops, its marts of commerce and finance? On the other hand, the typical Englishman, on his first visit to the United States, opens his eyes in astonishment, if not horror, at the radical innovations in lines which he had deemed fixed.

More intimate observation of results is apt to enlighten both peoples, and each may adopt somewhat of the other's point of view, until gradually they come together, more or less, as the international yacht designers have done. The process of assimilation, or mutual modification, seems to be now taking place in many ways, among others in the extended use of automatic machine tools in England and in some methods of shop management in the United States.

English visitors to American industrial establishments have frequently expressed their astonishment at the freedom of access gen-

erally accorded to foreigners and this fact was recently commented upon by another writer, a well known English engineer, in a contribution to the symposium upon American competition already alluded to. This writer says: "The American and British manufacturers exhibit a marked difference in their willingness to impart information. The American, as a rule, will, without hesitation, take anyone through his works, show any novel methods which he may have adopted, and generally supply any information which his visitor may be anxious to acquire. English and Continental manufacturers do not thus open their works to the public and are not anxious to supply information." Apropos of this the following incident, related in the *Marine Review*, may be cited here:

"Lieut. Harold P. Norton, of the navy, who is inspector of machinery for the United States cruiser *Albany* at the Armstrong shipyards, Newcastle-on-Tyne, England, has been having a hard time trying to get some detailed information about the torpedo-boat destroyers *Turbinia* and *Viper*, which have been advertised as the most wonderful vessels ever designed in regard to speed. He was permitted to inspect the engine and the boiler-rooms of the *Turbinia*, but not to see them while the vessel was running, and he had to be satisfied with walking around the outside of the building where the turbines for the destroyers were being built. He was not even allowed to look through the doors."

It is difficult to understand the reason why the builders of the *Turbinia* and *Viper* should object to inspection of these vessels, constructed under patents issued to Mr. Parsons. If, for example, these boats had been built in the Cramps' ship yards in Philadelphia under the protection of patents, the very opposite plan would probably have been pursued. Representatives of other governments would have been invited to inspect the vessels, and perhaps to be present at the trial trips.

It is, no doubt, true that American visitors, if properly introduced —and especially if they are not engaged in similar manufacturing occupations—are sometimes escorted through the workshops in Great Britain and on the Continent; but is it not also true that secrecy is, according to the generally accepted European idea, the key to success in manufacturing? It is not true, moreover, that this system tends to preserve and perpetuate methods and machines which have elsewhere been discarded as obsolete?

A few years ago an American visitor to some English establishments was surprised at the difficulty he experienced in obtaining ac-

cess to the workshops, and still more surprised and amused to find, eventually, that the carefully guarded machines and processes of manufacture would have been considered quite out of date in his own country.

Having thus briefly indicated certain radical differences in customs which have prevailed in the past in methods of management in Europe and America, it is the purpose of this paper to present evidences of a gradual but clearly perceptible change which appears to be now taking place on both continents, and the reasons therefor. In Europe it is noticed that more liberal views are developing, while in America the tendency is to draw closer the lines of policy in these matters of internal management of large industrial establishments. An illustration of this change may be found (in the foot note), in an article recently printed in the New York *Sun*. *

It is undoubtedly true that, with the keen competition in nearly all lines of manufacture, the man who invents a new machine or discovers a new and valuable process secures an immediate advantage over his competitors, which he naturally desires to hold as securely as possible for his own benefit, either by obtaining patents, or by preserving his improved methods as trade secrets. It is sometimes a puzzling question to decide which is the better means to this end.

If the novelty be a concrete form of machine, he will generally

* "A German manufacturer who visited Pittsburg recently was surprised by the difference between the welcome he received then and about eight years ago. When he was here on the previous visit the manufacturers of Pittsburg gave an international entertainment and dined and wined their competitors from England, Germany and France, showing them the wonders of natural gas and the resources of their plants. One day the programme called for a visit to the Carnegie and other mills, and this particular German was invited to go and see how things were done in this country, he being a steel manufacturer himself. He refused the invitation on the ground that German manufacturers had nothing to learn from America, and he had come to the United States to get away from the clangor and smoke of the steel mills.

"It was different last week. Having asked permission to inspect a certain mill and see the improved machinery and methods he had heard and read about, he was surprised at finding it would be impossible to obtain the required permit, and was obliged to content his curiosity with an inspection of a smaller establishment which was not in his particular line of business. Other foreigners have succeeded in entering some of the mills, but manufacturers are becoming more and more chary in granting facilities for the inspection of their plants, and the time will soon come when experts from abroad will have to content themselves with an exterior view of Pittsburg's manufacturing establishments.

"There is a great contrast between the period when foreigners cared nothing for a visit to the mills here and the present time, when they are arriving here for that very purpose every day. The reasons all lie in the new position the United States have taken in the eyes of the nations since the close of the Spanish war. American armor plate may have had no opportunity to show its excellence in the naval battles of that contest, but the voyage of the Oregon demonstrated the value of American machinery. Military science may not have been enriched with records of great strategic manœuvres, but American vim, thoroughness and rapidity of execution, initiative and other valuable qualities were shown in the army by officers and privates. Much, probably, of the interest now shown by foreigners is due to the fact that even before the war American manufacturers had cut into the

protect himself by patenting his invention, and the present tendency in such cases is to cover every possible improvement or modification that may be thought of by introducing a multitude of subsidiary clauses in the patent specifications, or else to secure a number of separate patents upon different parts of the machine. A remarkable illustration of this tendency to complexity of detail in patent applications is afforded in a patent issued a few months ago to a Philadelphia inventor, in which the claims allowed number one hundred and seventy-eight and fill eighteen columns of the fine type, closely set, of the U. S. Patent Gazette.

Some years ago two well known chemists and metallurgists discovered an ingenious process of obtaining chromium, tungsten, manganese, and other so-called "rare" metals, free from objectionable impurities and at comparatively small cost. Considerable sums of money were spent in obtaining European and American patents. I have been informed by one of these gentlemen that they have excellent reasons for believing that their processes are being extensively pirated in the preparation of certain alloys which are used in making special kinds of steel, both in the United States and in Europe; yet they have found it difficult, if not impossible, to obtain positive evidence of these illegal practices. For this reason, these experts are convinced that

markets of their foreign competitors; but most of it, so steel makers here say, is due to the sudden opening of eyes caused by the swift conduct of the war.

"At any rate, foreign manufacturers have been coming here in droves. It is only lately that the local industry has awakened to the commercial risk of permitting promiscuous inspection of the mills. The foreign expert need not bring a camera along to catch the improvements on machinery; his trained eye takes them in as quickly, and the photograph imprinted on his mind can readily be developed on his return home.

"Every plant has machinery that may not be patented in order to prevent others from making and using it, and its secret should, therefore, be guarded jealously. Machinery in everyday use here could, of course, be obtained by the foreigner from the regular makers, but there are things besides machines which help to American success. Thus, knowledge of improved methods of assembling and utilizing machinery may be useful to the foreigner, and should be kept from him. Many labor-saving methods are used in the best establishments, and it might be best that a competitor in search of knowledge should be held in ignorance of these. One mill may have evolved a smooth, rapid, apparently involved, and yet simple system—once it is understood —of manufacturing, say, beams, from the molten metal to the finished product loaded on the railroad car. This system was, perhaps, thought out after the loss of much money in expensive experiments; it would obviously be unwise to allow some competitor to learn the secret of the network of ladles, railroad tracks from furnace to furnace, cranes and overhead travelers and other devices intended to save labor and facilitate execution. Krupp, the great German manufacturer, acquired this lesson long ago, years before Americans had learned its A B C. No outsider can penetrate to the laboratories of the great German chemical establishments, and the commercial value of this precaution to the technical sciences may be deduced from the fact that the Germans have discovered 70 per cent. of the products of coal tar and have built up a monopoly that is annually worth millions of dollars to them.

"Of course, foreigners are still coming to Pittsburg to learn, but more than one mill has shut them out, and the time will soon come when they will be obliged themselves to evolve the application of the methods by which their markets are being taken away from them."—*New York Sun.*

a serious error of judgment was committed in patenting the processes and thus advertising them to the world.

About seven years ago, a sample of a crude artificial product was submitted to me for examination and opinion as to the advisability of patenting the process of making the material, which, it was believed, was capable of valuable practical applications in the arts. The material in question was an organic compound, and in order to form a correct judgment in the matter specimens were submitted to several analytical chemists (who are specialists in organic chemistry), for analysis and report upon the materials used and the probable method of manufacture. The chemists' reports agreed fairly well as to the component elements of the compound, but the analysts differed widely in the guesses—for they were mere guesses—as to the original materials and processes employed. One chemist frankly stated that he did not believe it was possible to answer the question, because an analysis of the product did not reveal the secret of its manufacture. On the strength of these reports, no patents were taken out for the compound, but a large amount of money was expended in developing the practical application to numerous uses. A successful business has resulted.

Several years ago a certain new metallurgical process was devised and put into practical use which differed greatly from all previously known methods, and although various attempts have been made to reproduce the process they have failed, for the reason that the imitators have been unable to grasp the fundamental principles involved. Quite recently, a graduate in chemistry and metallurgy from one of the leading technical schools in the United States became an employee in the establishment where this process has been in use very successfully on a large scale for about ten years, and after having observed the process and its results he admitted that it is based upon principles diametrically the opposite of those taught in his Alma Mater to this day. This is only another evidence of the truth of the statement recently made by Dr. Coleman Sellers in an address on the occasion of the seventy-fifth anniversary of the founding of the Franklin Institute that "the shops are always in advance of the schools." There was no "Catechism of the Locomotive," said Dr. Sellers, when Mr. Baldwin first built his locomotives. There were no text books of machine tools, worthy of the name, in Dr. Sellers's youth. The text books came afterwards, and it is perhaps not an exaggeration to say that no new book upon any practical art is, or can be, quite "up to date" when issued. Even the illustrated catalogues of manufactur-

ing establishments are confessedly never complete, so rapid are the changes and so frequently do the improvements follow each other.

An English visitor to a large machine-tool establishment in the western States gave a description of an immense machine tool which he had there seen, and stated that it is the largest of its kind in the world. Before these words appeared in print in England, a few weeks ago, three similar but much larger machines were in process of construction in an eastern establishment.

Other illustrations of this kind could be given, but these are sufficient for the present purpose; the main object of this paper being, as stated, in the first place, to show the gradual changes now taking place in the management of European and American industrial works, growing out of more frequent observations and of adoption of some of the salient features wherein radical differences have formerly existed; and, secondly, to discuss the important question of the advisability of patenting or of keeping secret new discoveries and inventions.

It is, of course, essential in a discussion of this character that the particular processes of the particular establishments alluded to should be but vaguely mentioned. The point, however, which it is desired clearly to elucidate is that it is usually unwise to patent a process, for the reason that, in order to procure a patent, it is necessary to describe the discovery accurately, so that anyone skilled in the art may reproduce it, and thus to open the door to infringement. On the other hand, assuming that a patent for an invention of a new machine has been broadly and accurately drawn, there is usually nothing to be gained by concealment, and everything to be gained by giving the widest publicity to the invention.

As the result of observation in some large establishments, and of inquiry elsewhere, I believe that it is becoming more and more the policy of manufacturers in America to keep secret improvements in processes of manufacture, and while visitors are, and probably will continue to be, cordially welcomed and even permitted to make investigations more fully than they can do at present in European establishments, these secrets are now as carefully guarded in American shops as in foreign factories.

While the foregoing is a broad statement of reasons why the patenting of a novel machine may be, and generally is, a wise procedure, and the patenting of a process inadvisable, there are exceptions to all rules. For example, in many establishments special machines have been devised and constructed which are not manufactured for sale,

and are, therefore, not patented; these are carefully guarded from the public view in order to prevent competitors from copying the designs. Again, a judicious re-arrangement of the standard machines may contribute to enlarged output and decreased cost of product; this systematic arrangement of plant is not patentable, yet it may represent much thought, labor, experience, and expenditure of time and money, and may enable one manufacturer to undersell another, other things being equal. It is natural that the owner of such a model plant should adopt precautions to prevent knowledge of these improved methods from becoming public property.

There is, of course, danger that secret processes and unpatented improvements in machinery, or in methods of manufacture, may be discovered by visitors who are familiar with the nature of the business; there is also the risk that employees may be enticed away, and there are many other ways by which unscrupulous outsiders may obtain knowledge of the most carefully guarded secrets. However, one who attempts to imitate or reproduce a secret process from a partial description or examination of the product will usually discover that there is some "missing link" which he cannot find, because the intangible idea, emanating from the brain of the original discoverer, is somehow and in some degree bound up in the process, if not indeed, an integral part of it; and imitations are never equal to the genuine articles. Apropos of this an incident may be related which recently came to my knowledge. A metallurgist offered to sell to a large manufacturing establishment the secret of a process for which great claims were made by him, and he was permitted to give some practical demonstrations. It was soon found that his process was identical with one which had been successfully introduced several years before by an employee of the works.

There is no doubt that the free interchange of ideas and experiences of persons engaged in similar lines of manufacture tends to the general advancement of any art, but there is, apparently, a growing feeling that this has been somewhat overdone in America, and it is now becoming more difficult for visitors to obtain permits to inspect the large industrial establishments of the country. Within the past few years, or since the great invasion of American manufactured products, especially of iron and steel, in many foreign markets, there has been a marked increase in the number of foreign visitors, engineers, mechanics, and other experts, chiefly from Great Britain and Germany, to the large industrial establishments of the United States, and several of

these visitors have given the results of their observations to the engineering world.

These articles are highly instructive to those who have not had equal opportunities of noting the great progress made in American methods of manufacture in recent years. Reading between the lines, one can perceive that these experts have made good use of all their faculties of observation and have carried home many valuable new ideas. It is far from my desire, or intention, to express the slightest regret on this account; I merely wish to record a few facts gathered from different sources which seem to indicate the probability of a coming change in policy of American manufacturers with respect to these matters of administration.

In conclusion it may be well to point out more distinctly that there are many cases where the question of patenting or keeping secret a new invention does not arise, or is easily solved. Thus, if a manufacturer of machine tools invents a new or improved machine, which he wishes to sell in quantities, and which therefore he must exhibit, he will not hesitate to patent it, for if kept secret he could find no purchasers; but if the machine is especially adapted to the improvement of his own products, or the reduction of cost, he may find it more to his pecuniary advantage not to patent the machine, but to keep it under lock and key. So also, if the chemist of the rubber trust, for instance, should evolve a new chemical process by which a low-grade crude rubber could be made to do equal duty with the purest Para article, the managers of the trust would surely endeavor to keep the process as secret as the Sphinx.

The difficult questions lie between these extremes, and it is as the case in hand approaches the one or the other that the manufacturer or inventor must balance the probable advantages and disadvantages in deciding whether or not to seek a patent.

THE WORLD'S SUPPLY OF COPPER.

By Frederick H. Hatch.

THE question of the world's copper supplies has received considerable attention ever since it has become apparent that, in spite of a constantly increasing production, there has been no accumulation of public stocks, showing that the industrial consumption of the metal has at least kept pace with production. One consequence has been a rise in prices, culminating in the metal boom of the year lately closed. The position may be gauged by an inspection of the following tables, of which No. I. shows the world's production and consumption of copper for the last ten years as calculated by the Frankfort Metallgesellschaft.* No. II. shows the position of the public stocks in Europe and America and shipments afloat for Europe on the 31st of December for the last ten years, and No. III. gives the average price obtaining for copper during the last eleven years.

TABLE I.

WORLD'S PRODUCTION AND CONSUMPTION OF COPPER FOR TEN YEARS.

Year.	Production. Tons of 2,240 lbs.	Consumption. Tons of 2,240 lbs.	Year.	Production. Tons of 2,240 lbs.	Consumption. Tons of 2,240 lbs.
1889	262,084	265,137	1894	324,195	326,624
1890	276,440	284,000	1895	345,143	349,360
1891	283,300	296,171	1896	386,340	380,000
1892	303,685	307,807	1897	410,347	414,056
1893	299,803	295,411	1898	420,950	423,510

The increased consumption of copper is, in the main, due to the expansion of the electrical industry, especially in installations for power transmission; although, at the same time, there has been a greater demand for copper in other industries, such as ship-building and marine engineering. It is in the United States that the greatest strides have been made, and that country now stands first with a copper consumption for 1898 of 117,050 imperial tons against 104,320

* Statistical compilations of the Metallgesellschaft and the Metallurgische A. G., Frankfort on Main, 1899. The figures in these compilations, being given in metric tons, have been converted to imperial tons of 2,240 lbs.

The enormous increase in the demand for copper, which has been occasioned by the rapid expansion in the electrical industries, is probably without precedent in any line of metal production. Already the problem of finding a substitute is being actively studied, and aluminum is being put into use.

Dr. Hatch's comprehensive view of the world's resources appears at a significant time. Necessities of space confine the detailed study in this issue to the three greatest producing countries; the subject will be concluded in the April issue of THE ENGINEERING MAGAZINE. THE EDITORS.

TABLE II.

POSITION OF PUBLIC STOCKS ON DECEMBER 31, FOR TEN YEARS, IN TONS OF 2,240 LBS.[1]

Year.	Shipments Afloat for Europe.	Public Stocks in Europe.	Public Stocks in America.	Total Stocks, English, American and Afloat.
1889	5,400	93,400	29,000	127,800
1890	3,900	61,400	45,000	110,300
1891	3,400	52,600	33,900	89,900
1892	5,000	50,700	25,000	80,700
1893	4,500	42,500	26,000	73,000
1894	3,900	50,700	36,000	90,600
1895	2,900	42,700	38,800	84,400
1896	3,600	31,300	37,000	71,900
1899	4,500	27,400	21,800	53,700
1898	5,500	22,300	24,000	51,800
[2]1897	5,300	17,517		

TABLE III.

AVERAGE PRICE OF COPPER PER TON OF 2,240 LBS., FOR TWELVE YEARS.

	London prices.[3]									New York Prices.[4]	
	Tough Cake.			Best Selected.			Chili Bars or G. M. B.s.			(Lake Copper.)	
Year.	£.	s.	d.	£.	s.	d.	£.	s.	d.	Cents per lb.	£ per ton.
[5]1888	77	17	0	79	11	4	81	8	1	16 2/3	77
1889	53	18	5	55	3	10	49	11	4	13 3/4	63 1/2
1890	58	19	10	61	11	10	54	7	7	15 3/4	72 3/4
1891	54	12	4	56	11	2	51	12	8	12 7/8	59 1/2
1892	48	14	0	49	18	10	45	15	7	11 1/2	53
1893	47	0	8	48	3	11	43	16	4	10 3/4	49 1/2
1894	42	16	10	43	12	8	40	9	6	9 1/2	43 3/4
1895	46	5	9	47	1	4	43	2	8	10 3/4	49 1/2
1896	49	17	8	50	13	8	47	0	6	10 7/8	50 7/8
1897	51	12	0	52	5	8	49	3	6	11 1/3	52 1/4
1898	54	14	8	55	9	8	51	17	9	12	55 3/8
[6]1899							73	17	3		

The following is Messrs. H. R. Merton & Co.'s statement of prices for G. M. B.s, for each month of the year 1899.

Month ending,				Month ending,			
Jan. 31	£69	10s.		July 30	£76	5s.	od.
Feb. 28	71	0		Aug. 31	76	15	0
Mar. 31	70	0		Sept. 30	75	15	0
April 30	77	0		Oct. 31	72	17	6
May 31	76	15		Nov. 30	73	15	0
June 30	76	15		Dec. 31	70	0	0

[1] From "A Century of Copper," by Nicol Brown, London, 1899.
[2] H. R. Merton & Co.'s Circular of Statistics of Copper.
[3] Blue Book on Mines and Quarries, pt. 3, p. 182, 1899.
[4] Statistical Compilations of the Frankfort Metallgesellschaft, 1899, p. 20.
[5] Inflation of prices brought about by the French copper ring, led by M. Secretan.
[6] Average of monthly prices to December 15, 1899. (H. R. Merton & Co.)

tons for 1897. Germany also shows a great advance, owing to the vigorous growth of the electrical industry. The figures for 1898 and 1897 are 95,486 and 88,380 tons respectively. Excepting Austria, which has required an additional 1,500 tons, no other country has increased its consumption. Great Britain shows a considerable falling off, the figures for 1898 and 1897 being 96,908 and 103,605 tons respectively.

CONSUMPTION OF RAW COPPER DURING FIVE YEARS. IN METRIC TONS.

	1894.	1895.	1896.	1897.	1898.
United States	88,569	118,835	95,966	105,998	118,925
United Kingdom	100,661	83,476	104,247	105,263	98,459
Germany	56,145	63,813	79,438	89,798	97,014
France	30,689	37,738	43,224	51,869	48,536
Austria, Hungary	14,744	12,748	14,598	17,063	18,687
Russia	11,700	13,500	17,600	18,600	16,100
Italy	6,344	6,641	6,968	7,790	7,566
Belgium	5,000	5,000	5,500	6,200	5,800
Netherlands	2,400	2,400	2,400	2,400	2,400
Other European Countries.	2,100	1,900	2,100	2,200	2,100
Exports from Europe	1,500	1,400	1,500	1,200	1,300
Japanese Copper in Eastern Asia	12,000	7,500	12,500	12,300	13,400
Total consumption	331,852	354,951	386,041	420,681	430,287

The world's production of copper at the beginning of this century was about 8,000 tons per annum. By the middle of the century it had increased to 20,000 tons per annum. By the year 1880 it had reached 150,000 tons, and by 1888 was more than 250,000 tons per annum. Five years ago it had passed 320,000 tons, and it is now more than 420,000 tons per annum.

An interesting compilation by Messrs. Nicol Brown and C. C. Turnbull * shows that the present century has furnished the world with over 8,000,000 tons of copper, and that the total production by the end of the century will be more than 9,000,000 tons. At the present rate of production and without allowing for any increase, the next century would see a total output of 40,000,000 tons of copper. And if production continues to increase during the next decade at the same rate as it has done during the past, it will amount to 700,000 tons per annum by 1908. Are our present known sources of copper sufficient to meet these gigantic requirements?

Thinking a review of the present supplies of copper would throw some light on the possibilities of the future, I have put together the

* "A Century of Copper," London, 1899.

following notes on the chief mining districts from which the bulk of metal is derived. Some of these I have personally visited (Huelva in Spain, Butte and Lake Superior in the United States, Rossland in British Columbia, Sudbury in Ontario); with regard to the others I have drawn on numerous scientific and statistical publications to which references are given.

The order adopted is that of the importance of the individual contribution to the world's output, as shown in the following table.

TABLE GIVING THE PRODUCTION OF FINE COPPER FOR 1898 IN VARIOUS COUNTRIES.*

Country.	Tons of 2,240 lbs.
United States	237,173
Spain and Portugal	53,225
Japan	25,175
Chile	24,850
Germany	20,085
Australasia	18,000
Mexico	10,435
Canada	8,040
South Africa	7,060
Russia	6,000
Norway and Sweden	4,095
Italy	3,435
Peru	3,040
Bolivia	2,050
Newfoundland	2,100
Austria-Hungary	1,540
United Kingdom	640
Argentina	125
Algeria	50
Total	427,118

The total output of the world, as given in this table, differs from that already given for 1898 on page 869. This difference is due to the different methods of computation adopted in the two cases. The above table gives the amount of copper derived from the ores mined in each country, although the metal may be actually produced by smelting and refining operations in another country. The other figure was arrived at from smelters' and refiners' returns of raw copper produced from foreign and native ores and intermediate products and from official statistics of export, import, etc. A comparison of the sum of the outputs for ten years brings the two estimates into close agreement.

It will be seen from this table that by far the greatest producer is

* Compiled from H. R. Merton's "Principal Copper Supplies" for 1899 and Rothwell's "Mineral Industry" for 1898.

the United States, that country having furnished in the year about 55½ per cent. of the world's total supply of the metal. Spain and Portugal make a bad second with 12½ per cent. Then comes Japan with 5¾ per cent.; Chile with 5¾ per cent.; Germany with 4¾ per cent.; Australasia with 4¼ per cent.; Mexico with 2½ per cent., and the remaining 9 per cent. is made up by the other countries.

The rapid growth of the copper production of the United States is remarkable. That country has more than doubled its output in ten years, the mineral production for 1888 having been only 101,710 tons. The same feat has been accomplished by Australasia and Japan, the former country having produced in 1888 only 7,450 tons, and the latter 11,600 tons. During the same period Mexico has increased her output by 7,670 tons; Canada hers by 5,800 tons; Germany hers by 4,855 tons; Peru hers by 2,800 tons, and Norway and Sweden theirs by 1,800 tons, while Chile has fallen from 31,240 tons to 24,850; the United Kingdom * from 1,700 tons to 640, and Venezuela from 4,000 tons to *nil*. The production of Spain and Portugal has remained fairly constant at 52,000 to 54,000 tons.

Although copper had been discovered on the shores of Lake Superior by the Jesuit fathers as early as the end of the seventeenth century, and a little desultory mining had been done at points near the Atlantic coast during the eighteenth century, yet before 1840 the copper production of the United States was inappreciable.† In the forties, however, a few mines began to produce in the lake country (Cliff, Phœnix, Minnesota, etc.) and in the Appalachian States (Ely mine in Vermont, Bristol mine in Connecticut and the Perkiomen mine in Pennsylvania;‡ and since the year 1846 there has been a steady growth of production up to the present date, as will be seen in the table on the following page.

The copper supply of the United States at present is derived chiefly from three sources, viz.: Montana (Butte), Michigan (Lake Superior) and Arizona, these three States producing over 90 per cent. of the total. Other States contributing, but in far smaller quantities, are California (Shasta County), Colorado, Utah, and a few eastern and southern States.

The table on the following page gives the production from these sources for the last five years.

* In 1830 Great Britain produced over one-half of the world's output of copper.

† See Dr. Houghton's geological report to the legislature of Michigan in 1841.

‡ A very interesting historical account of the copper industry of the United States is given by James Douglas in *Iron Age*, Jan. 2, 1896.

TABLE GIVING THE COPPER PRODUCTION OF THE UNITED STATES FROM THE YEAR 1845 TO 1898, IN TONS OF 2,240 lbs.*

	Tons.			Tons.	
1845	100	W	1872	12,500	A
1846	150	W	1873	15,500	A
1847	300	W	1874	17,500	A
1848	500	W	1875	18,000	A
1849	700	W	1876	19,000	A
1850	650	W	1877	21,000	A
1851	900	W	1878	21,500	A
1852	1,100	W	1879	23,000	A
1853	2,000	W	1880	27,000	A
1854	2,250	A	1881	32,000	A
1855	3,000	A	1882	40,470	M
1856	4,000	A	1883	51,570	M
1857	4,800	A	1884	64,700	M
1858	5,500	A	1885	74,050	M
1859	6,300	A	1886	69,805	M
1860	7,200	A	1887	79,109	M
1861	7,500	A	1888	101,710	M
1862	9,000	A	1889	105,774	M
1863	8,500	A	1890	116,325	M
1864	8,000	A	1891	128,179	M
1865	8,500	A	1892	152,620	M
1866	8,900	A	1893	147,210	M
1867	10,000	A	1894	157,814	R
1868	11,600	A	1895	172,524	R
1869	12,500	A	1896	208,710	R
1870	12,600	A	1897	221,958	R
1871	13,000	A	1898	237,173	R

OUTPUT OF THE SEVERAL STATES, IN TONS OF 2,240 lbs.†

State.	1894.	1895.	1896.	1897.	1898.
Montana	81,739	86,950	102,213	105,874	96,866
Michigan	51,128	57,920	64,312	65,107	71,010
Arizona	19,880	21,575	32,922	36,170	49,475
California	54	101	880	6,308	9,618
Colorado	2,914	2,734	4,259	4,213	4,853
Utah	528	1,190	1,585	1,721	2,404
Eastern and Southern States	1,088	1,453	1,674	1,664	1,999
Other sources	483	601	915	901	953
Total	157,814	172,524	208,760	221,958	237,178

* See "The Mineral Industry," 1899.

† Compiled from various sources, viz.: Whitney, "Mineral Wealth of the United States," 1854 (W); "Annual Review of the New York Metal Exchange" (A); H. R. Merton & Co.'s annual circular, "Principal Copper Supplies," (M), and "The Mineral Industry," 1899 (R).

Montana.—The copper production of this State is practically restricted to a small granite area not exceeding two square miles in extent, situated on the eastern slope of the Rocky Mountains. The mines are situated in the neighbourhood to the town of Butte, which, with the town of Anaconda, exists solely to minister to the mining and smelting industries. Butte is situated on the Northern Pacific Railway and is connected with Anaconda by the Butte, Anaconda and Pacific Railway, the distance being twenty-seven miles.

The ores worked by the Butte mines are chiefly sulphides of copper (chalcocite, bornite, and chalcopyrite), with which is associated the arsenide of copper (enargite). They occur in irregular vein deposits in the granite. The veins, which vary from a few inches up to more than a hundred feet in width, consist of the above mentioned minerals in a quartzose gangue. Near the surface they carried silver, but very little copper, and in some cases (as, for instance, the Anaconda), the mines were started for the exploitation of silver ores, the value of the copper deposits being only realised in the course of subsequent development.

The mining companies at present producing copper at Butte are the following: *

Mines.	Production during 1898. Tons of 2,240 lbs.
Anaconda	47,830
Boston and Montana	27,700
Montana Ore purchasing	5,885
Parrot	5,586
Butte Reduction Works	4,324
Colorado Smelting and Mining Co.	3,420
Butte and Boston	3,120
Hecla Cons. Mining Co.	58
	97,923†
Less copper in purchased ore	1,057
Total	96,866

The ores vary greatly in value according to the nature of the vein filling; but the average grade may be gauged by the output of the Anaconda group of mines, which contribute about 50 per cent. of the

* "Mineral Industry," 1899.

† The total is somewhat in excess of that already given for the whole production of the State of Montana, but this is due to copper derived from purchased ore being included in the above returns.

total output of the district. During the year ending June 30, 1898, the company operating these mines treated at their reduction works 1,459,249 short tons * of ore, and shipped 124,417,471 lbs. of copper, 5,074,036 ozs. of silver, and 16,610 ozs. of gold, which is equivalent to a yield of 4.26 per cent. of copper, 3.48 ounces of silver, and 2 dwts. of gold per ton of 2,000 lbs.†

Michigan.—Next to Montana, Michigan produces the largest amount of copper of any of the United States. Here also the copper-bearing deposits are confined to a comparatively small area—the Keweenaw promontory on the south shore of Lake Superior. The metal occurs native, associated with sandstone conglomerate and amygdaloid trap (diabase), forming an interbedded series (Keweenawan series), of Pre-Cambrian ("Algonkian") age. The strike of the beds is N. E. and S. W. and the dip N. W., *i. e.*, towards the lake, at an angle of 40° to 55°. The average copper contents are small, but the extent and size of the ore bodies and the simplicity of ore treatment are conditions favourable to cheap and consequently profitable working.

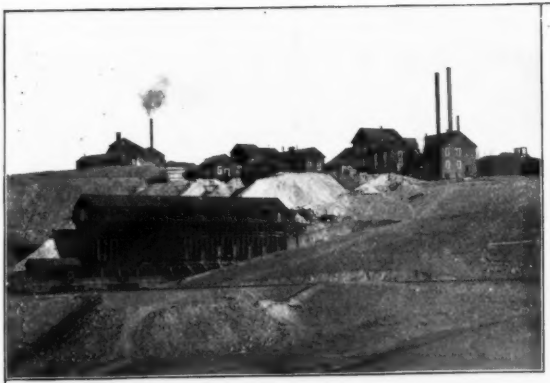
Three classes of deposit yield copper at Lake Superior: 1, Beds of conglomerate consisting of pebbles of acid eruptive rock (rhyolite) cemented in part by native copper. 2, Sheets (flows) of basic volcanic rock (diabase) in which metallic copper is found impregnating the rock in strings, flakes, specks, and irregular masses, or lining the calcite filling of vesicular cavities. 3, Veins, intersecting the bedded rocks, and occasionally carrying large masses of native copper.

The conglomerate beds are the chief source of the lake copper, 70 per cent. of the total production being derived from the famous Calumet and Hecla and the Tamarack mines on these beds. The former company possess a large property in which the bed is being worked from the outcrop downwards. The Tamarack property is situated on a portion of the deep levels of the Calumet.

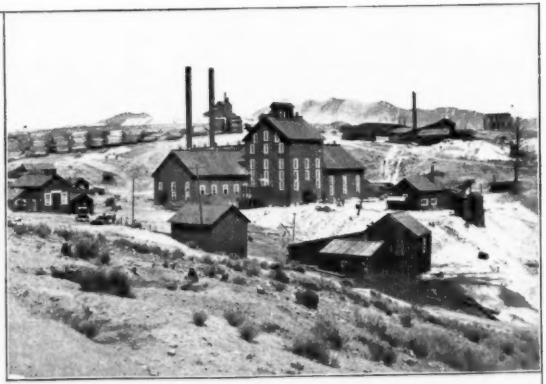
These mines are the deepest in the world, the workings extending to a vertical depth of nearly a mile from surface. Thus the Red Jacket shaft of the Calumet and Hecla has a vertical depth of 4,900 ft., while of the four shafts of the Tamarack, No. 2 is 3,649 ft. deep; No. 3, 4,450 ft., and No. 4, 4,450 ft. No. 5 will be 5,500 ft. when complete. The average stoping width is about 16 feet, while the yield of copper from the ore worked by the Tamarack during 1898 was 1.56 per cent. The Calumet and Hecla does not publish details.

* Third annual report of the Anaconda Copper Company.

† Tons of 2,000 lbs., dry weight.



High Ore mine.

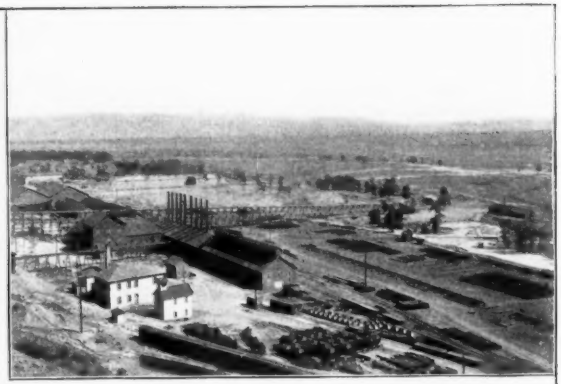


Niagara hoisting works.
Green Mountain mine.

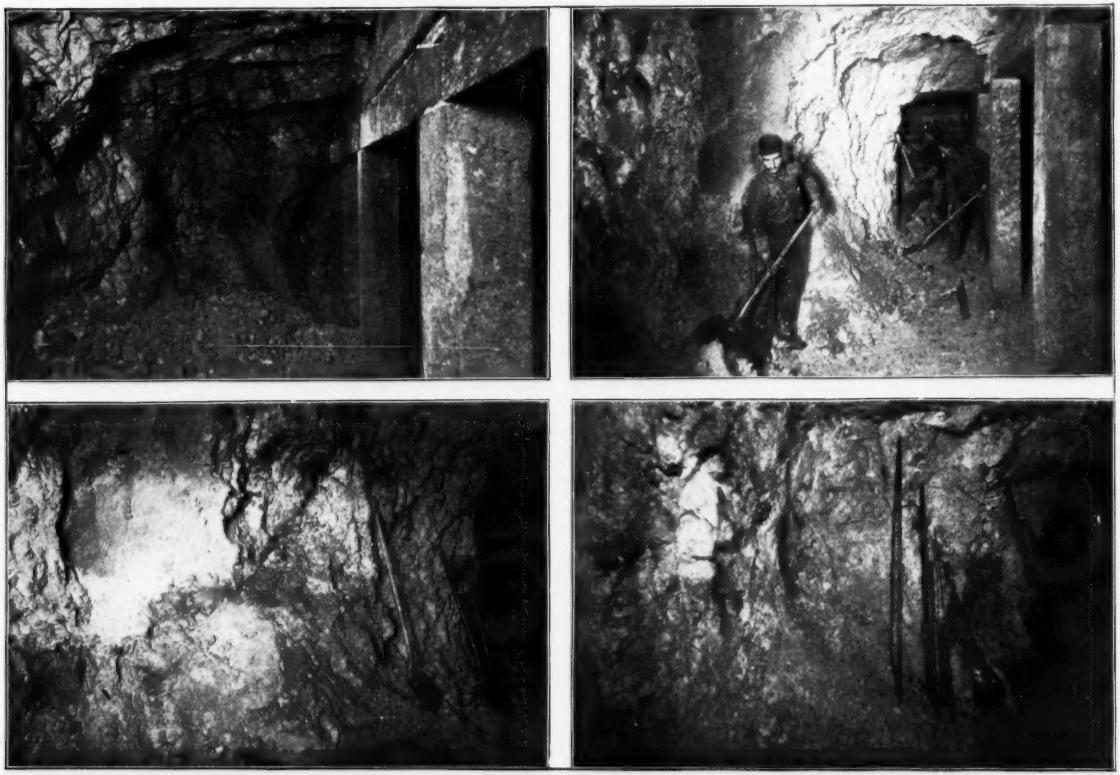
Anaconda hoisting works.

SOME OF THE MINES OF BUTTE, MONTANA.

Upper works and Anaconda.
Butte and the Anaconda mines.



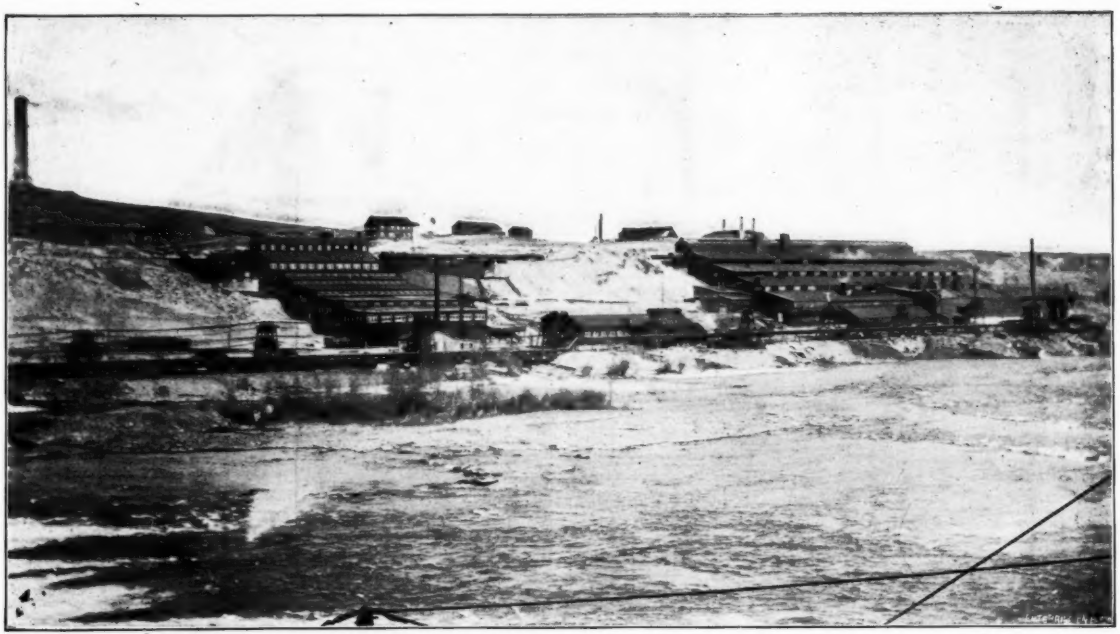
Panorama of lower works, Anaconda.
Panorama of Anaconda and the smelters.



A fine ore body, with part of the timbering.
A fine ore breast, untimbered.

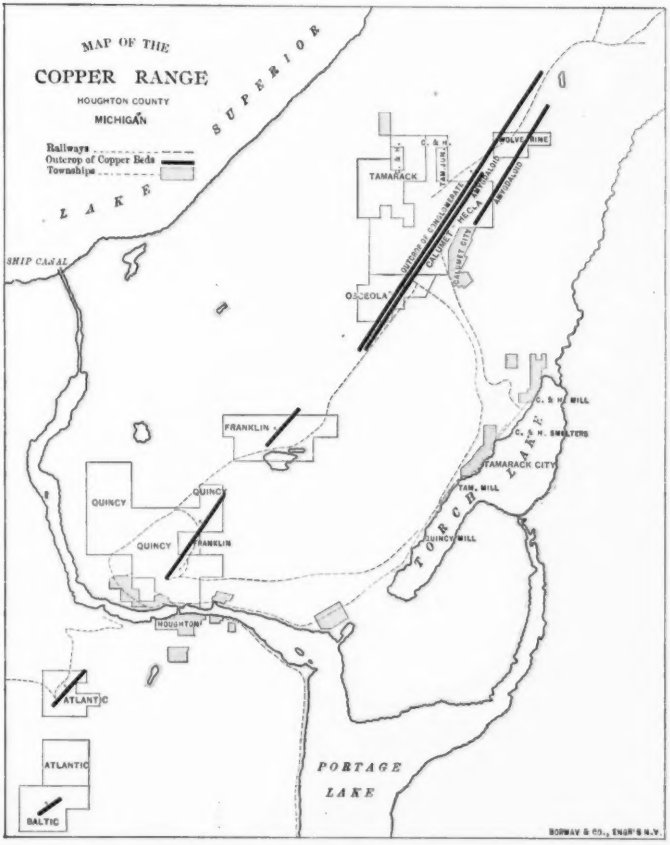
East sill floor breast. Miners at work.
East sill floor breast, without timbers.

UNDERGROUND WORKINGS, MT. CON, ANACONDA PROPERTIES.



From the Copper Manual. By permission of D. Houston & Co.

SMELTER OF THE BOSTON AND MONTANA CONSOLIDATED COPPER AND SILVER MINING CO., GREAT FALLS, MONTANA.



The diabase beds are worked profitably by several mines, notably by the Osceola, Atlantic, Quincy, Wolverine, and Franklin. The bed worked by the Atlantic has an average width of 15 ft. Its copper contents are low, the average yield for 1898 being only 11.8 lbs. of copper to the ton of ore, or 0.59 per cent. The yield of the Quincy is 1.56 per cent., and that of the Wolverine 1.334 per cent.

The vein deposits occur either parallel to the bedding of the formation or cut across it. They are of less commercial importance than the bedded deposits, but are remarkable for the large masses of metallic copper that have been found in them. One such mass,

found in the Central mine, weighed 600 tons. The tenour of the vein mines is, however, uncertain and few of them have been worked continuously at a profit.

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IN THE TAMARACK MINE, MICHIGAN.

The output of the several mines worked in the district during 1898 was as follows:

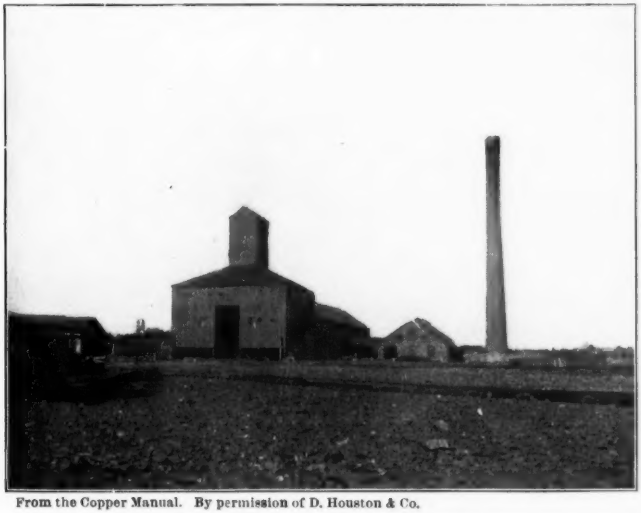
Mines.	Tons of 2,240 lbs.
Calumet and Hecla	41,101
Tamarack	10,045
Quincy	7,301
Osceola Consolidated	5,268
Wolverine	2,408
Atlantic	1,959
Franklin	1,593
Central	1,300
Baltic	19
National	8
Other sources	10
	71,010

As the copper contents of the Lake Superior ores are in the form of native metal of remarkable purity, the metallurgical treatment is extremely simple. That adopted by the Calumet and Hecla Com-

pany may be taken as typical. The ore is crushed by 22 Leavitt stamps with steam cylinders, each having a duty of 250 tons per diem. After dressing with Collum jigs and Evans slime tables, the metal is run down into ingots, which are subsequently refined in the reverberatory furnace.

Lake copper is much esteemed for electrical purposes on account of its high conductivity, and consequently commands about ⅛ of a cent. per lb. more than the current price of electrolytically-refined copper from other sources.

Arizona.*—The Arizona copper mines are famous for their large yield from oxidised and carbonated ores of copper of such purity as to permit of a single smelting to black copper by fusion with coke in water-jacket furnaces. The oxidised ores are associated with carboniferous limestone, which seems to have favoured the genesis of the secondary ores. As the mines get deeper, however, the sulphide



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RED JACKET SHAFT, CALUMET AND HECLA MINES, MICHIGAN.

ores begin to appear, but in most cases a rich partially oxidised product is found occupying an intermediate position between the unaltered sulphide† and the oxides and carbonates.

* A large amount of valuable information relating to the Arizona copper districts is given by James Douglas in the "Mineral Industry" for 1898.

† Except in the Verde mines, oxidation has extended to a depth of 400 to 500 feet.

There are four important copper producing districts—the Clifton, Bisbee, Globe, and Jerome. In the Clifton district, which is situated near the eastern boundary of the State, copper-bearing veins occur in limestone, in felsite, and in granite. The oxidised ore consists of copper oxide (cuprite) in a gangue of manganese ore (wad). In the Longfellow mine, which may be taken as a typical example of the limestone veins, the ore occurs in bunches connected by thinner branches following the planes of stratification or by cross seams in the limestone. In some of the mines, rich intermediate products are found (*e. g.* chalcocite), which in depth gives place to poorer pyritic ore (chalcopyrite). Fortunately the character of the pyritic ore permits of concentration, the sulphides being distributed through an earthy gangue which can be partially removed by wet dressing before smelting.

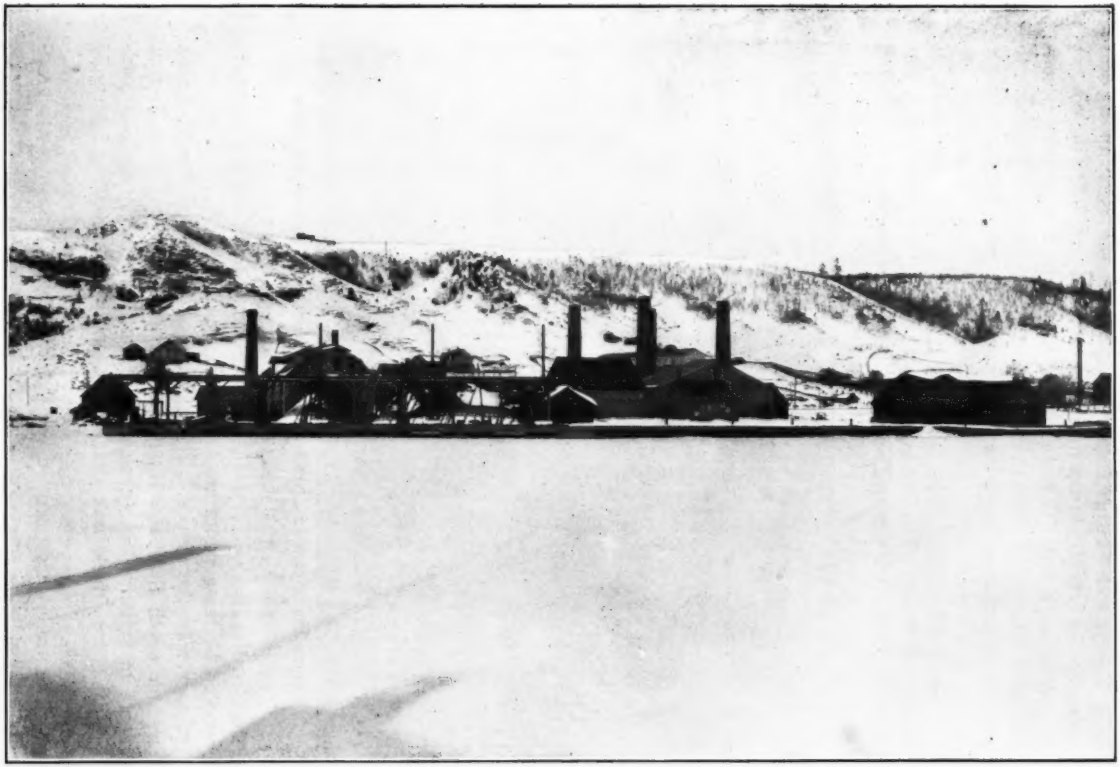
The mines of this district are operated by two companies—the Arizona Company, owning the Longfellow and other mines, and the Detroit Company, whose headquarters are at Morenci. The district is estimated to have produced, since the initiation of serious mining operations in 1872, nearly 90,000 tons of copper.

The Bisbee district is in the Mule Pass Mountains, Cochise County, in the southern part of the State, near the Mexican border. The ore bodies occur in limestone and consist of large masses of ferruginous clay, carrying copper in the form of carbonate down to a depth of 400 feet, after which the sulphide ores are found. At the junction of the oxidised with the pyritic ores there is often a rich secondary deposit of chalcocite.

At first the oxidised ores were smelted to black copper in a single fusion; but now matte smelting and Bessemerisation in converters has been adopted for treating the mixed oxidised and sulphide ores. The Copper Queen is the principal mining company of the district. The ore occurs in this mine in huge chambers connected by thin strings.* Its total yield since commencing operations is stated to have been 85,000 tons. The average yield of the ores, after rough sorting, is about 8 per cent. of copper, and in addition there is a small amount of gold and silver amounting in the average to about $1 per ton.

The Globe district is situated in Maricopa County, in the central portion of Arizona, north of the Gila River, and has hitherto been rather inaccessible for want of adequate railway communication. This, however, has now been remedied by the completion of the Globe,

* A. F. Wendt: Trans. Amer. Inst. Min. Eng., Vol. XV., page 63.



From the Copper Manual. By permission of D. Houston & Co.

QUINCY SMELTING WORKS, HANCOCK, MICHIGAN.

Gila Valley, and Northern Railroad. The ore bodies occur in great chimney-like deposits in the limestone near and parallel to the contact of intrusive diorite. The ore consists of oxide, but contains a considerable amount of silica, necessitating the addition of limestone to the furnace charge. A pure black copper is produced by a single fusion in water-jacketted furnaces.

The total output from the district since the commencement of mining operations has exceeded 40,000 tons. At present two important companies are working, the Old Dominion and the United Globe.

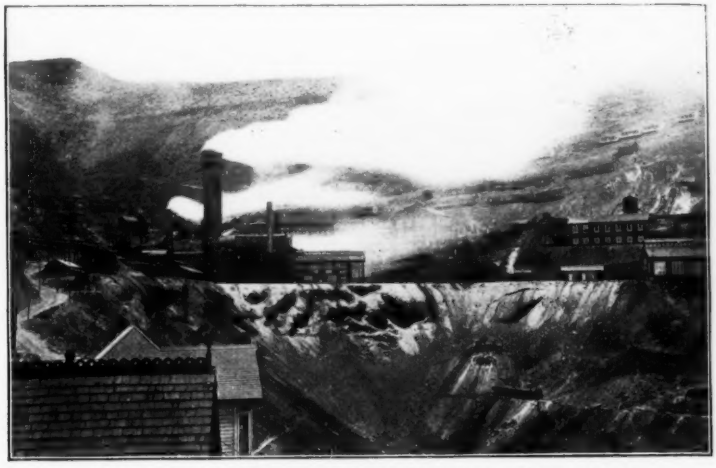
MINES AND WORKS OF THE UNITED VERDE COPPER CO., JEROME, ARIZONA.

The Jerome district is situated in Yavapai County, on the eastern slope of the Black Range and near the Verde River. The ore bodies worked by these mines are lenticular masses lying in slate near the contact with the diorite. The oxidised zone does not extend to a greater depth than 150 ft., copper carbonates giving place at that depth to sulphide ore (chalcopyrite), while at the junction oxysulphides occur which have yielded much rich ore containing both gold and silver.

The present treatment of the United Verde Company is to heap-roast the sulphide ore preparatory to matte-smelting in blast furnaces, with subsequent Bessemerisation in converters.

The output of copper from Arizona for 1898 is summarised in the following table:

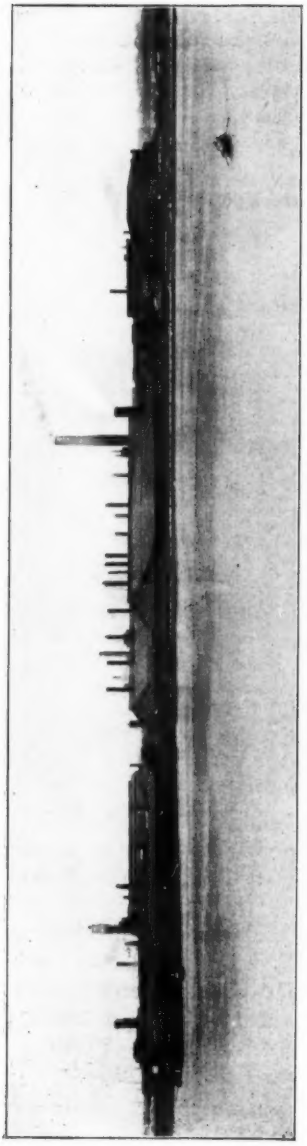
District.	Mine.	Tons of 2,240 lbs.
Jerome	United Verde.	18,900
Bisbee	Copper Queen	15,066
Clifton	Arizona Copper Co.	8,111
	Detroit.	5,102
Globe	United Globe.	1,271
	Old Dominion.	804
Other mines	Estimated.	220
Total		49,474



MINES AND WORKS OF THE UNITED VERDE COPPER CO., JEROME, ARIZONA.

California.*—The only important producer in this State is the Mountain Copper Company, whose property (the "Iron Mountain") is situated near Keswick in Shasta County. The Shasta ore belt extends over several miles, striking N. E. from the Iron Mountain deposit towards the Sacramento River, the town of Redding on the Southern Pacific Railway, between San Francisco and Portland, being the main base of supply. The ore bodies consist of large lenticular masses of ferruginous material impregnated with copper sulphides. The county rock in which the deposits lie is a variety of granite or porphyry. The ore has an average copper contents of about 7½ per

* See H. A. Keller, in the "Mineral Industry" for 1898, and M. M. O'Shaughnessy in "California Mines and Minerals," San Francisco, 1899, p. 205.



WORKS OF THE ORFORD COPPER COMPANY, CONSTABLE'S HOOK, NEW JERSEY.

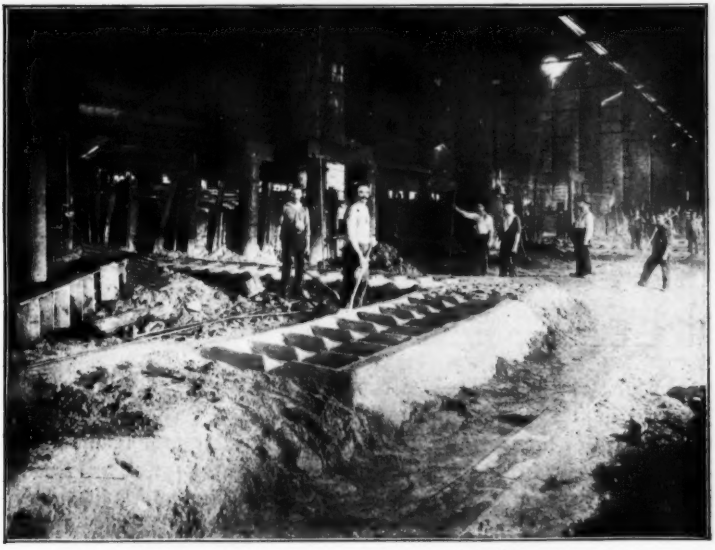
cent., and contains small amounts of gold and silver. It carries much sulphur and iron, but is deficient in silica and consequently requires the addition of siliceous material for fluxing. The gossan ores, which extend from the surface to a depth of 125 ft., have richer gold and silver values, but practically no copper, this metal having been extracted by an atmospheric leaching process.

The smelting plant is situated at Keswick, with which the mine is connected by a narrow-gauge railway. The process consists of first roasting in stalls, the roasted ore being smelted in water-jacketted blast-furnaces with the addition of siliceous material and coke. The resulting matte, containing 45-50 per cent. copper, is shipped to New Jersey for further treatment. The Mountain Copper Company has now produced for three years, the amount of copper shipped in the form of matte, during these years, being as follows:

1896...	812	tons of	2,240 lbs.
1898...	6,205	"	"
1897...	9,572	"	"

Colorado and Utah.—The output of copper in these States is derived principally as a bye-product from the smelting of silver-lead and silver-copper ores in the Leadville and San Juan Districts, only one mine, the Calumet, near Salida, being worked for copper alone.

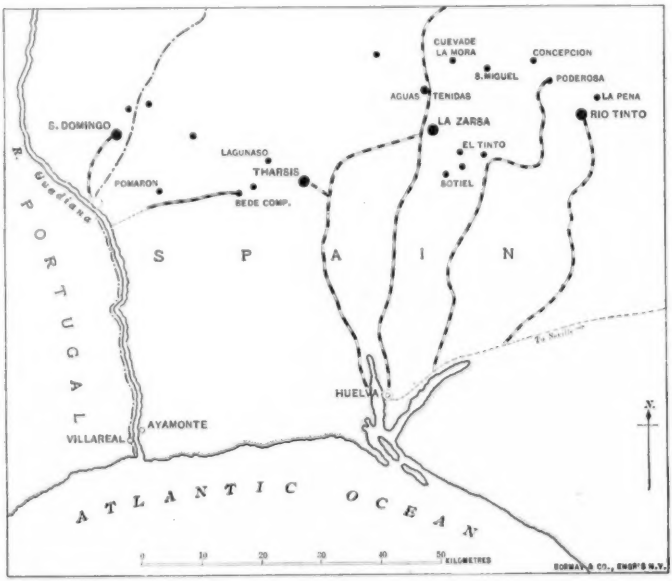
CALCINING FURNACES, ORFORD COPPER COMPANY'S WORKS.



BLISTER FURNACES, ORFORD COPPER COMPANY'S WORKS.

A similar condition of things prevails in Utah, the silver smelters producing there a large proportion of the copper as a bye-product The La Sal Copper Company, however, is smelting copper ore from mines recently opened in the La Sal Mountains, near the Colorado boundary.

Eastern and Southern States.—The Appalachian States (Vermont, Virginia, Georgia, Tennessee, North Carolina, and Alabama) were once great producers, but the output is much reduced and many mines are closed, although there still exist, in the metamorphic rocks of these districts, considerable stores of low-grade copper pyrites which, with a good price for the metal, could doubtless be worked at a profit.



Spain and Portugal.—The copper mines of Spain and Portugal produce, at the present time, over 50,000 tons of metallic copper, or 12 per cent. of the world's total output. This large production comes almost entirely from the Huelva District in the south of Spain. Huelva is a port on the Atlantic coast, near the Portuguese boundary, and is the base of a mining district extending from Seville to the Portuguese boundary, one of the important mines (San Domingo), ly-

ing just within Portuguese territory. The copper mines have been famous since the earliest historical times. It is supposed that the Phœnicians visited the Spanish coast and worked copper as early as the eleventh century B. C. Certainly the Romans did an enormous amount of work in these fields, as shown by the ancient tunnelling and shafting in the mines and by the huge piles of débris accumulated at the surface. During the four centuries that the Romans worked there they are supposed to have extracted close to 1,000,000 tons of metallic copper. During the Moorish occupation no work was done in the mines, and, although mining was resumed by the Spaniards after the expulsion of the Moors, the production was of small account until the middle of the present century.*

By 1860 the production had risen to about 3,000 tons, by 1865 to about 6,000 tons, in 1870 it was roughly 13,000 tons, and in 1875 20,000 tons. More exact statisics are obtainable since 1880, the production being given by Merton & Co. as follows:

Year.	English Tons of Fine Copper.	Year.	English Tons of Fine Copper.
1880	36,313	1890	51,700
1881	39,258	1891	53,915
1882	39,560	1892	56,462
1883	44,607	1893	53,995
1884	46,415	1894	54,175
1885	47,873	1895	54,950
1886	49,653	1896	53,325
1887	53,706	1897	54,060
1888	56,450	1898	53,225
1889	54,270		

The ore-bodies consist of large lenticular masses of cupreous pyrites occurring in slate formation of Lower Silurian age and associated with intrusive igneous rocks (porphyries and diabases). Only a small proportion of the pyritic mineral is chalcopyrite, the remainder being iron pyrites. The copper percentage is small; during 1898 that of the Rio Tinto ore averaged 2.85, and the copper extracted 2.32 per cent., while other mines work ore of still lower grade. The ore, which is won in large open-cut workings, is partly treated at the mines by the cementation process (precipitation by pig or scrap iron after atmospheric oxidation and solution), and partly shipped to Europe, where the sulphur oxides obtained by roasting the ore are

* See Gonzalo y Tarin: "Descripcion Fisica Geologica y Minera de la Provincia de Huelva," Madrid, 1886-38; and Vogt: Das Huelva Kiesfeld, Zeitsch. f. Pract. Geol., 1899, p. 241.

utilised for the manufacture of sulphuric acid, while the burnt ore is subsequently treated for the extraction of the contained copper, gold, silver, and iron. The three principal mines are under English management, viz., Rio Tinto, Tharsis (a Scotch company), and San Domingo (Mason and Barry).

The output of the mines has probably reached its limits, as will be seen by the following table * giving the production of fine copper in tons, 2,240 lbs., for the last five years:

Year.	Rio Tinto.	Tharsis.	San Domingo.	Sevilla.	Other Mines.	Total.
1894	33,000	11,000	†4,200	1,170	4,805	54,175
1895	33,500	12,000	†4,100	1,050	4,300	54,950
1896	33,000	12,000	†3,900	1,025	3,400	53,325
1897	33,900	†12,000	†4,300	800	3,120	53,225
1898	33,705	†12,000	3,600	810	3,050	54,060

Japan.—This country has long been an important producer of copper. The metal was discovered as early as A. D. 698, but smelting on a large scale was not carried on until the beginning of the sixteenth century. Between the years 1609 and 1858 the annual production is estimated to have averaged 2,800 tons per annum, of which a large proportion was exported by the Dutch and Chinese merchants. ‡ At the present time about half the total production goes to domestic consumers. The output for five years is as follows:§

Year.	Tons of Fine Copper. (2,240 lbs.)
1894	20,050
1895	18,430
1896	21,000
1897	23,000
1898	25,175

The ore-bodies consist of veins of low-grade sulphide ores (chiefly chalcopyrite, but with some chalcocite and bornite). Oxidised and carbonate ores appear to be rare. The most important mines are situated in the north of Nippon, in the Province of Rickuchin. Among the largest producers may be mentioned the mines of Ashio, in the district (ken) of Totsigi, Ani and Osarisawa, in the district of Akita, Besshi in the district of Yechine, and the Ozaka mine in the district of Sakai. There are also important mines on the Island of Shikoku, for instance the Kumayama, in the district of Jehime.‖

* Merton & Co., Principal Copper Supplies.

† Estimated.

‡ Dr. Geerts estimated that during these years 280,000 tons (of 2,000 lbs.) were exported by the Dutch and 250,000 tons by the Chinese merchants. Trans. Asiatic Soc.

§ H. R. Merton & Co., Copper Supplies.

‖ See Munroe, Tran. Amer. Inst. of Min. Eng., 1877, p. 235.

THE WORLD'S SHIP-BUILDING.

By Benjamin Taylor.

IN all the history of industry we shall search in vain for any year to equal that which has recently closed. For five years there has been a gradual ascent from the vale of depression in which commerce and industry had so long languished. That ascent became accelerated in 1898, and in 1899 we reached a high-level in both hemispheres. Not a little of that industrial activity is ascribable to the enormous demand for sea-carriers and sea-fighters. Every country in the world has been bent on increasing the merchant navy, just as every maritime power in the world has been adding to its naval armaments. Shipping is not only one of the oldest occupations of man, but it affords more employment than any other industry in the world. Three-fourths of the earth's population are dependent on ship-building, shipping, and sea commerce. But ship-building is a very different thing from what it was in the good old days of the New England shipbuilder, of whom Longfellow has sung. "Ship" is a wide term. It includes Noah's ark, the Oregon, and the submarine Holland. But as the world keeps spinning down the ringing grooves of change, it is a comfort to know that a ship need never cease to be a thing of beauty. We lament the lovely curves and the swelling sails of the Baltimore clippers, but were these craft more beautiful in their way than are in theirs those graceful and stately monsters of the Oceanic and Campania type, which now churn the Atlantic? Whether or not, we have got to put up with the monsters, whose coming has both created and been created by an industrial and mechanical revolution.

About 2,500,000 tons were added to the world's ocean shipping in 1899—a total of some 200,000 tons over even such a prolific year as 1898, and far beyond precedent. The proportion of the United Kingdom, according to the trade returns (but not according to Lloyd's Register, to which we shall presently refer) was 1,731,543 tons built in private yards and in government dockyards. We will first show

The interest of a review of ship-building—the greatest of all engineering industries—needs no demonstration. It is, however, especially instructive to compare the magnificent figures of England's output, under a free-ship policy, with the barren returns from the United States, where blind efforts are still being put forth to bolster up an artificial "protective" system under which American shipping has nearly been driven from the sea. It will be of interest to review Mr. McKechnie's articles on Ship-Building as a Productive Industry in Great Britain, Dec., '97—Mar., '98; Mr. Dunell's on The Prospective Expansion in American Ship-Building, Apr., '99, and Rudolph Haack's on The Development of German Ship-Building, Aug.-Nov., '99.—THE EDITORS.

what the United Kingdom has done, according to the reports of the builders themselves.

OUTPUT OF UNITED KINGDOM.

	1899. Tons.	1898. Tons.
Scotland.		
Clyde	491,074	466,832
Firth	15,642	26,624
Tay	17,908	14,292
Dee	11,973	7,449
England.		
Tyne	307,951	307,324
Wear	268,508	262,969
Tees	144,101	146,624
Hartlepool	139,600	119,040
Humber	32,287	33,880
Mersey	13,584	4,026
Thames	21,205	38,294
Barrow and Union Ports	66,887	51,079
Government Dockyards	69,100	73,090
Ireland.		
Belfast, etc.	131,723	121,330
Total U. K.	1,731,543	1,672,853

And the following is an estimate of the world's output of tonnage:

	1899. Tons.	1898. Tons.
United States	267,600	237,600
Germany	260,000	171,800
Canada	5,000	18,000
Holland and Belgium	59,000	49,200
Norway and Sweden	28,000	26,360
France	62,000	26,770
Italy	46,000	22,900
Denmark	23,000	13,250
Russia	40,000	20,000
Austria	10,000	11,650
Spain and Portugal	7,000	120
Japan	12,000	11,420
China	5,000	——
Singapore, etc.	3,600	——
Other Countries	10,000	10,000
	838,200	619,070
United Kingdom	1,731,543	1,672,853
Total World	2,569,743	2,291,923

Lloyd's returns differ from these compiled from the figures supplied by the builders, and for this reason, that builders include craft of all sorts and sizes, whereas Lloyd's exclude everything under 100

tons. According to Lloyd's figures, there were 714 merchant steamers of 1,414,774 tons and 12 sailers of 2,017 tons, in all 726 vessels of 1,416,791 tons, and 35 warships of 168,590 tons displacement—a grand total of 761 vessels of 1,585,381 tons—built in the United Kingdom last year. These totals exceed those of the "record" year 1889 by 207,000 tons in merchant vessels, and by 127,000 tons in warships. It was practically all steam tonnage last year, whereas in 1889 10 per cent. of the output was in sailing vessels, and in 1890-93 the proportion of sailers was 19 per cent. Stated in percentages, the proportion of sailers to steamers built in 1899 was just about 0.13 per cent. Of the total British output, upwards of 80 per cent., or about 1,150,000 tons, were added to the British register. Per contra, that register was reduced by 273,000 tons in wrecks and by 640,000 tons of old vessels sold to the colonies and foreign countries. This last item, again, has a set-off in the shape of purchases from foreign and colonial owners to the extent of 77,000 tons. It follows from all this that the net increase in British effective tonnage on the seas was about 313,000 tons, which exceeds the addition of 1897 by 265,000 tons, but is less than the addition of 1898 by 14,000 tons.

Rather less than 20 per cent. of the British output was for foreign and British colonial owners, as compared with 22 per cent. in 1898, 25 per cent. in 1897, and 30 per cent. in 1896. These figures show a decreasing demand on British builders as a consequence of the development of ship-building in other countries, but it is well to remember that the totals of recent years were considerably swelled by the requirements (now satisfied for the present) of Japan for warships and big mail steamers. Notwithstanding the development of her own ship-building, Germany is still the largest buyer of British vessels, having taken in 1899, 19 steamers of 68,057 tons, this comparing with 9 steamers and 37,045 tons in 1898, and with 8 steamers of 30,507 tons in 1897. The next largest customer for British ships was Austria, 36,837 tons; followed by Norway, 28,419 tons; Spain, 25,586 tons; Denmark, 23,597 tons; Holland, 22,312 tons; Russia, 14,984 tons; Sweden, 9,346 tons, and Belgium, 8,279 tons. The British colonies took from the mother country 14 vessels of 17,904 tons, as against 12 of 19,022 tons in 1898 and 17 of 23,009 tons in 1897. These are merchant craft, in addition to which British builders launched for other countries 17 war vessels of a displacement of 47,450 tons, including a ship of 3,770 tons for the United States. At the end of the year, British builders had on hand for foreigners 30 warships of a total of 84,305 tons displacement in various stages of construction. For the

British Government, they had on hand 36 warships of 199,530 tons displacement, in addition to 15 ships of 139,920 tons in various stages of construction at the Royal Dockyards.

Lloyd's estimates for the United States do not correspond with the figures issued by the Bureau of Navigation which we have adopted in the foregoing estimate. They summarise thus:

UNITED STATES TOTAL OUTPUT

	1899.		1898.	
	No.	Tonnage.	No.	Tonnage.
Steamers	421	160,132	550	169,602
Sailers	533	107,510	405	67,998
Total	954	267,642	955	237,600

UNITED STATES LAKE AND RIVER OUTPUT.

Lakes	70	72,094	66	75,067
Rivers	112	11,942	111	14,605
Total Inland	189	84,036	177	89,672

Deducting the tonnage constructed for inland navigation, we find the United States last year turning out for ocean and coasting navigation 765 vessels of 183,606 tons, as compared with 778 vessels and 147,928 tons in 1898.

OUTPUT OF VESSELS OF MORE THAN 100 TONS.

COUNTRY.	Built in 1895. Tons.	Built in 1896. Tons.	Built in 1897. Tons.	Built in 1898. Tons.	Built in 1899. Tons.
Austro-Hungary	18,471	11,796	8,851	11,632	11,548
Belgium	1,270	1,675	1,899	833	423
British Colonies	10,381	11,124	12,431	25,021	8,464
Denmark	10,982	14,014	13,539	12,703	30,083
France	70,922	105,500	64,526	101,718	155,674
Germany	94,126	117,345	191,042	168,405	252,464
Holland	9,447	21,015	25,871	30,294	39,144
Italy	18,943	28,709	48,816	29,366	66,952
Japan	5,096	7,849	11,390	11,424	6,775
Norway	12,873	12,059	17,248	22,670	27,853
Portugal	.....	.....	.....	442	1,917
Russia	5,669	28,196	5,913	31,938	34,305
Spain	9,949	7,830	9,765	.....	.....
Sweden	2,767	8,375	6,984	12,985	11,707
Turkey	.....	.....	.....	760	400
United States	96,911	200,477	94,598	240,900	233,408
	367,807	575,964	512,873	701,091	881,117
Deduct Warships	100,614	167,833	133,435	175,318	176,170
Total Merchant Tonnage	267,193	408,131	379,438	525,773	704,947

The disagreement between Lloyd's figures and those of the Bureau of Navigation with regard to the output of the United States is unfortunate, because it rather vitiates the foregoing comparative statement of the world's output outside of the United Kingdom. It extends over five years, and, allowing for what we have just said, it affords a very good idea of how ship-building has progressed and is progressing beyond the British Isles.

And the following, compiled from Lloyd's returns, shows the tonnage of vessels of more than 100 tons in course of construction in each of the countries on the 31st of December in the last five years:

COUNTRY.	1895. Tons Gross	1896. Tons Gross.	1897. Tons Gross	1898. Tons Gross.	1899. Tons Gross.
Austro-Hungary	.....	4,500	700	8,186	14,600
Belgium	...	2,850	.....	4,000	4,300
China	150	.....	275	300	10,825
Denmark	5,587	15,445	3,403	14,738	12,114
France	37,458	68,898	50,978	73,934	102,086
Germany	80,324	104,739	84,071	168,134	200,180
Holland	13,400	16,015	20,956	22,696	31,555
Italy	6,820	15,120	22,310	61,500	107,950
Japan	417	10,930	16,785	10,000	4,432
Norway	5,066	9,926	14,626	22,160	21,959
Quebec	... ...	.....	140	.....	530
Singapore	715	949	.....	250	.....
Spain	949	... ...	.....	.....	2,000
Sweden	1,816	2,850	4,100	4,425	3,040
United States	24,275	19,627	18,552	69,645	104,384
	176,977	271,849	236,896	454,968	619,955

Our own figures show the development to be even greater than Lloyd's reveal.

Amongst seven largest builders in the world last year were two German firms. Thus:

	Tons.
1. Harland & Wolf, Belfast	82,634
2. Wm. Gray & Co., West Hartlepool	77,500
3. The Vulcan Co., Stettin	68,712
4. The Furness Co., West Hartlepool	62,100
5. Blohm & Voss, Hamburg	59,300
6. The Armstrong-Whitworth Co., Newcastle-on-Tyne	57,550
7. Russell & Co., Port Glasgow	52,500

As the world's output in 1899 included 345,000 tons of warships, we may take it that the addition to the world's supply of mercantile tonnage was about 2,250,000 tons, from which have to be deducted the losses by wreck and natural decay.

It is practically impossible to grasp the amount of power involved in the production and employment of this tonnage. The numerals to which we habitually attach the initials i.h.p. afford but a very imperfect conception of even the motive portion of it. And yet it is practically all we can reduce to terms of type. Ship-building and marine engineering are nowadays practically convertible terms, at all events, in Great Britain, where the sailer has "passed." But every ship-builder is not a marine engineer, nor is every builder of marine engines a builder of ships. In connection with ships, the following was the engine power production of the United Kingdom:

	I. H. P.
Clyde-built marine engines	478,503
Firth " " "	15,556
Tay " " "	22,030
Dee " " "	12,310
Tyne " " "	276,379
Wear " " "	139,119
Tees " " "	85,200
Hartlepool " "	45,000
Humber " "	45,000
Mersey " "	35,000
Barrow " "	34,500
Thames " "	90,000
Other ports " "	25,000
Belfast " "	96,280
Total	1,399,877

American readers may perhaps not be prepared to find so large a proportion—more than one-third—of marine-engine power of the United Kingdom produced on the Clyde. Yet the Clyde did not show the largest individual total last year. First place among British marine-engine builders was occupied by Messrs. A. Laing & Co., Wallsend-on-Tyne, with 67,600 i.h.p.; the second by Messrs. Harland & Wolff, Belfast, with 66,150 i.h.p., and third place by Messrs. John Brown & Co., Limited (late Clydebank Shipbuilding & Engineering Co.) Glasgow. The world's record, however—88,300 i.h.p.—is held by the Vulcan Company, Stettin, who, as we have seen, were also third on the list of ship-builders.

Such production as we have indicated in the capacity and motive power of vessels indicates that in every producing centre the resources of ship-yards and engine-shops were taxed to their utmost capacity. When it is recalled that in the early part of 1898 the operations of British builders were to a considerable extent restricted by the engineers' strike, which was not really terminated until February of that year, it does not seem such a great thing that the addition to the

British output in 1899 was only some 60,000 tons, while the increase of the rest of the world was about 200,000 tons; we cannot put it at more, as the returns from some of the countries are illustrative rather than authoritative. But the explanation is that in Great Britain production was seriously retarded—especially in the latter portion of the year—by the very tardy delivery of building material, owing to the inability of makers to get prompt and sufficient supplies of crude iron and fuel. The same difficulty is still being felt, and a good deal of the tonnage that has been put into the water this year (1900) would, under normal conditions, have come under the records of output in 1899. At the beginning of 1900 there were "under construction" in the shipyards of the United Kingdom 1,306,751 tons of merchant vessels and 423,755 tons of warships, some of which last, however, being off the stocks, have been included in the launches of 1899. As regards merchant vessels, the tonnage on hand at the beginning of 1900 was about 95,000 tons less than at the beginning of 1899, but the total of this year may, nevertheless, exceed that of last.

In the case of America and Germany, the development also is in the production of steam tonnage, but in France it is different. Practically three-fourths of the tonnage given on our list above as turned out in France last year was sailing tonnage, for France occupies the unique position of being the only country in the world which is adding to its fleet of large-sized sailing vessels. No fewer than 24 sailers of 2,000 tons each and upwards were launched from French yards last year. This is because, under the bounty system, this is the kind of vessel that can extract the largest amount of bounty from the State. The Ville de Mulhouse and the Ville de Havre, of 3,200 tons each, built at Havre, are the largest sailing vessels afloat. In French yards there were also under construction last year some 14 warships, which are not included among our figures of tonnage launched. These include one vessel of 9,400 tons for Japan, one of 3,160 tons for Brazil, and one of 350 tons for Russia, the rest being for the French navy.

It may be noted here that, besides these warships building in France and the 35 named above as produced in British yards for foreign navies, the only other warship-building for other countries reported by Lloyd's, is, in Germany, one of 9,850 tons for Japan, three of 1,050 tons for Russia, and two of 640 tons for Italy; and, in America, one of 6,500 tons for Russia.

In examining the compositions of the addition to the world's merchant fleet, three outstanding features are revealed, viz: (1), the increasing use of steel; (2), the increasing size of cargo as well as

passenger carriers; and (3), the increasing power and speed, both of passenger boats and of big cargo liners.

In the matter of materials, if we exclude the United States and Canada, there were probably not 10,000 tons of wood or "composite" vessels built in all the maritime countries. The proportion of such is not more than 0.1 per cent of the new tonnage. On the other hand, 98.8 per cent. of the new tonnage last year was of steel and 1.1 per cent. of iron. The new iron vessels were all of small tonnage, and consisted of steam trawlers and such like craft. We are, in fact, in the steel age of ship-building. Never before in the world's history was so much steel required as in 1899. Yet the probability is that the world's needs this year will be even greater. And in connection with this feature of the year has been the inevitable rise in the cost of construction, due to the great rise in the price of material in such general pressing and increasing demand. As to this, we shall have a word to say later on.

The temptation to review strictly naval work must be resisted, though some of the new vessels, and in England notably the Cressy, present many interesting features of improvement in armour and armament.

Except in the case of the Viper, there was last year no great novelty in mechanical appliances introduced, and the Viper herself is still a dark horse—but the more general adoption of the twin-screw is noticeable. And another feature was the number of cases in which merchant steamers adopted the water-tube boiler. The adoption is not, of course, by any means general—far from it—but it is a fact that ship owners seem gradually coming over to the views of the Admiralty with regard to this form of boiler. The outstanding mechanical feature of the year has been in the increase of the power per ton of merchant-steamers.

While the twin screw has become more general, it should be noted that in two new steamers of the Castle (Cape) line—Kinfauns Castle and Kildonan Castle, built on the Clyde—the single screw was reverted to. On the other hand, the German battleship Kaiser Karl der Grosse, of 11,000 tons, built by Messrs. Blohm & Voss, Hamburg, is fitted with three screws.

In illustration of the foreign work of the year, this Hamburg firm built a twin-screw of 12,400 tons, two twin-screws of 10,300 tons each, one of 10,500 tons, and one single-screw of 4,850 tons. The Vulcan yard at Stettin turned out a German warship, Kaiserin Maria Theresa, of 8,285 tons, the Patricia, of 13,290 tons, and the König Albert, of 10,-

040 tons. The Kaiser Wilhelm der Grosse battleship (not to be confused with the North German Lloyd liner of the same name), is of 11,000 tons, and was built by the Germania Company, at Kiel. The largest items of production of Holland, Italy and Russia were war vessels, none, so far as reported, exhibiting any novelty in type of structure.

Touching the structure of big ocean carriers, in order to secure size and speed, the use of nickel steel will become more common. Sir William White, of the British Admiralty, has calculated that in an Atlantic liner of 20 knots a weight of about 1,000 tons could be saved by using nickel steel instead of mild steel. The greater becomes the size of ships, the more important must this saving be. It is only within the last forty years that we have seen the evolution of steamers making over 11 knots, and at a much more recent period the fastest Cunarder did not exceed that speed. It was not the question of model, but of machinery and material—perhaps more of material than has been generally allowed. What mild steel has done in the past in the lightening of ships and the heightening of speed, we may expect to see nickel steel do—perhaps to an even more striking degree—in the future. But it must be much cheapened first. Who shall say what developments in structural matters we may see within the next ten years, when we remember that twenty years or so ago there was not a single vessel being built of steel?

This brings us to the question of cost, and undoubtedly the most striking feature of 1899 in an industrial sense has been the great rise in prices. By the rise in material, shipbuilders have been placed at a great disadvantage, for it is practically impossible to cover all material in advance when contracting to build a vessel, and, moreover, high price has been mainly caused by short supply, and short supply means irregular and delayed deliveries, to the general detriment of the operations of a yard and increase in the incidence of administrative and standing charges. As an example of the rise in cost, take steel plates. At the end of 1898 they were selling in Great Britain at £6 10s. per ton, and by the end of 1899 the price was £8 per ton. Within two years this particular item has advanced 50 per cent. Figuring upon plates we would estimate that a 5,000 or 6,000-ton boat, which in 1898 would have cost say £7 10s. per ton, could not now be built for less than £9 per ton. But other items have risen also—in fact, everything is so enhanced that the cost of building now may be taken as fully 50 per cent. more than the average cost of 1898, and perhaps from 60 to 70 per cent. more than the price at which steamers could be built two or three

years ago. This enormous difference has had the natural effect of checking the demand for new ships—especially as the cost of working a steamer has been greatly increased by the large advances in bunker coals and stores. Then the costs of the British builder are now much greater than they need be, by reason of the restrictive action of the trade unions—especially the two leading unions in the industry—the Boilermakers' and Iron Ship-builders' Society and the Amalgamated Society of Engineers. It is true that amicable working arrangements exist between the employers and both these unions, and that since the great strike of 1897-98, work has gone on with unwonted smoothness. But the union regulations will not allow a maximum output to be attained, nor the fullest results to be obtained out of machine tools. In the case of the Iron Ship-builders, the restrictions, irregular working, excessive wages, and unreasonable demands of the men are a constant cause of complaint and loss to the ship-builders; but, as it is said that the union officials are sincerely desirous of reforming the methods of their members, it may be hoped that a change for the better may be effected without such a struggle as occurred with the engineers. What is certain, is that, without a complete revolution in the labour conditions of her ship-yards, Great Britain will not be able to retain her position as the premier ship-builder of the world.

It seems to be now generally admitted that in normal circumstances (1899 being exceptional in the excess of demand over supply of iron and steel), the United States can produce ship-building material at a lower cost than British makers can. That being so, there remain only the factors of applied science and labour. In the case of the former, American builders lack only the experience of the high-class British builders. In the case of the latter, America has the advantage at present in fewer union embarrassments and in the more generous use of machinery. How long that advantage may last cannot, of course, be said, but what can be said by an impartial Briton is that America does not need a Shipping Subsidies Bill to enable her to build and to own a merchant navy worthy of her commerce. She has all the elements within her own industrial resources, without dipping into the national purse." Bounties have not helped to any extent either the shipping or the ship-building of France, but antiquated navigation laws do prevent the natural development of America. That at least is how it appears to a free trader.

THE REVOLUTION IN MACHINE-SHOP PRACTICE.

By Henry Roland.

VI.—THE MACHINE WORKS OF THE IMMEDIATE FUTURE.

CONSIDERING the successful shop of to-morrow, the preceding papers of this series may be said to point out certain conditions which must be met, in view of the close competition and the wide general apprehension of the vast importance of machine construction which now obtains, if future success in any branch of the art is to be hoped for.

First, the day of the large general shop, prepared to do business in all lines of machine building, has certainly passed and passed forever. It is, perhaps, true that there will continue to exist a great number of small repairing and general jobbing shops, supported by the various machine users in their immediate localities; it will always be the case, probably, that some of these small jobbing shops will, through some fortuitous conditions, develop into well appointed works producing only a limited line of work, meeting a wide demand both in price and quality; in this case the "jobbing" features of the establishment will naturally be dropped as rapidly as possible. In other cases, the small jobbing shops will give a decent support to the owner who attends closely and intelligently to the needs of his patrons, and to a small force of clever and versatile all-around mechanics under him, who prefer the variety and lack of strenuous effort of the small shop to the relentless crush towards the front in a single line, which must be the characteristic of the machine shop, light or heavy, of to-morrow.

As already clearly shown in these papers, there is a size limit of production which must do one of two things: it must either divide the shop into sharply defined light and heavy departments, or must divide the business itself into branches, separately housed and officered.

One important phase of machine-tool evolution—the geometrical evolution of regularly irregular metal surfaces, of which the gear-cutting machine affords the chief and most interesting example—has been necessarily left for an article supplementary to the series of which this paper is a summary. It will shortly be treated by Mr. Roland in a separate contribution to THE ENGINEERING MAGAZINE.

The series on The Revolution in Machine-Shop Practice began in the issue of this Magazine for October, 1899. The preceding topics have been:

The Evolution of the Tool Maker.
Development of the Automatic Screw Machine.
Application of the Turret to General Machine-Shop Work.
The Practical Limitations of Tool-Making.
Application of Automatic Mechanical Production to Heavy Work.

Whether the shop be light or heavy, it must be well lighted, well heated, well ventilated, and well provided with conveniences for the individual use of its workmen. These workmen's conveniences, now the exception—separate clothes lockers, separate washing facilities, and a good and well cooked mid-day meal at something less than actual cost—will very soon be regarded by machine constructors as absolutely indispensable, because in their absence the best workers cannot be had. The mid-day hot meal, giving a choice of various good dishes at trifling cost, is of the highest importance, and is in very successful operation in more than one instance. Perhaps these physical-life betterments of shop works which are directly profitable to the machine-shop owner may be listed in the following order. First, a white shop interior—walls white, ceilings white, all tools painted white; next, light—first, all the daylight possible, next abundant arc lights placed above reflectors directed upward; all old machine shops and many new ones are most miserably and most expensively dark; then perfect heating and ventilation, and a cheap hot meal at noon time in a comfortable room used exclusively for eating, not for smoking or lounging. These particulars give the worker a chance to work. To obtain workers of a high grade they must be clean, and must be individualized, and must not be, either in theory, treatment, or fact, mere numbered particles of a mass. The individualized worker, who is always the efficient worker, must have his own territory in the shop, his own clothes locker, his own wash-bowl, his own seat at the table, his own machine or vise, his own round of duties, his own consciousness of his own worth and value. Only a few years since what I have just said was not to be proved by existing examples. Now it is easy to refer to many examples covering every point specified.

Having thus equipped the factory so that a contented force of workers may be reasonably expected to take voluntary service in it, and to remain, the next point to consider is the best possible expenditure of animal force. Every man has within himself a certain and fixed possibility of continued exertion. Up to this limit his effort is a pleasure to himself, and hence is willingly made; beyond this limit he cannot go if he would, and it is the business of the manager and the tool-maker to see that the least possible expenditure of muscular exertion is made to produce the greatest possible return in finished product. To this end the general manager and his superintendents under him must see that the lines of movement of material in process of finishing are well planned, and facilitated by all possible aids in the way of travelling cranes and hoists of the character best adapted to the

work in hand. If the shop has more than one floor (and there are those who believe that the lantern roof and gallery floors make the best known form of heavy machine shop), then there should be abundant passenger elevators, each in charge of a special attendant. Let it be fully and clearly comprehended that each workman has his fixed individual limit of willing muscular exertion, and that the farther the maximum demand of shop exertion falls below that limit the brighter and more alert the individual workman will be during his hours of service, since nothing that moves, from a locomotive, a driving belt, or a line shaft, to the chief designer of the drawing room, can be profitably worked anywhere nearly up to the point of fatigue.

By the same reasoning, which applies to the general manager with an hundred fold the force with which it applies to the shop operative—because the manager must bear a hundred cares and responsibilities where the worker bears one—limit the lines of production until the manager can feel that no one in the whole world knows more of the true theory of the production and office of his specialties than he himself knows. When the manager reaches this point, he is indeed master of the business he controls. The fewer the subjects to which the manager must direct his attention, the more fully and thoroughly he can consider each one, and the less occasion he has to pass the limit of his profitable exertion, and to do things which he is not sure it is best to do simply because he is the only one to fill the gap.

Up to certain diameter limits, labor costs of machine production can be reduced to almost any extent. Given the demand for the finished product, and the tool-maker who can reduce the original labor cost by 50 or 75 per cent. of what originally appeared to be, and perhaps at one time was, the best possible practice, never fails to appear. This is undoubtedly true of all light machine construction, the word "light" extending only up to those diameter limits within which automatic machines and fixed cutters may be available.

For the heavy shop, most of the labor-cost reductions must be made in handling, and in furnishing the fullest facilities for thoroughly testing the finished product, and so avoiding all of those expenses and highly annoying delays that so often lie between shipment by the maker and acceptance by the purchaser. Too much stress cannot be laid on the importance of long continued shop tests, of the most complete and exacting nature, carried out by thoroughly reliable experts, under the control of chief inspectors of inflexible integrity and unswerving self reliance—men who will pass nothing faulty, and yet will not cause the shop needless expense for mere academic reasons.

Much consideration has been given to reduction of labor costs by the intellectual elevation of the operative. To most shop workers, as to most men in all walks of life, books are the mere husks and chaff of past harvests, and much book learning is to all such a loathly vanity, and very little real gain has come from the establishment of shop reading rooms and all those efforts which look to a lifting of the general intellectual level of the shop worker. To every large machine shop there will, however, come some bright young minds of the two or three strongly marked classes; those who are mechanics by intuition, skilful of hand and often fine draughtsmen, making small use of books, and of comparatively limited range of action, but infallibly correct within their limits; the few of real breadth, to whom books as well as things mean much, who grasp the full scope of their art, and, delving deeply into the records, have the capacity to make the monuments of past achievements the stepping stones to higher levels of future attainment; then those youths who know the whole of their own shops and have the poise and balance of things in their heads, and so develop in limited fields those executive powers which are indispensable to the success of large works. These bright young minds the wise manager will recognize, aid, develop, and forward with sedulous care, well knowing that the most valuable to him of all of his shop products are his home-made and home-trained leading men.

It is certain that very soon American ship-building will be a vast industry. At this moment the use of 1,200 tons of steel daily in the manufacture of pressed-steel freight cars is one of the causes of the present steel famine. Sixty-five years ago it was fully and clearly demonstrated, by costly practical tests, that all the work done on common roads by horses can be done more quickly, more safely, and more cheaply by mechanically propelled wagons, and there can be no possible doubt that this closing year of the nineteenth century will see the establishment of large American machine shops for the production of automobiles, thus giving to the machine shop the construction of the ships, the construction of railway equipment, and the building of the horses and wagons for use on common roads in both town and country, this last named division of the machinery of translation being of almost incalculable magnitude. The automobile in its heaviest forms is well within the limits of full automatic tool production, and we may look to the yet-to-be-evolved American automobile factories for examples of the very fullest development of the use of automatic machine tools, producing perfectly interchangeable self-driven wagons.

EDITORIAL COMMENT

There is in many quarters a mistaken idea that nearly all, if not all, of the mines in the Transvaal are dominated by British capital, and a consequent feeling that it is greed of British capitalists for the gold of South Africa which has had much to do with the present troubles there. As a matter of fact, both France and Germany have large, and in some cases, controlling interests in Transvaal mines, and the whole movement is simply one of the natural development of a rich country by the capital of civilised Europe.

This fact is clearly brought out by a communication from M. Henri Duval, the Director of the Johannesburg branch of the French Bank of South Africa in connection with his negotiations with the French and German consuls there in regard to action for facilitating the operation of the pumping machinery in the Rand mines. The Transvaal government being especially desirous of favouring the mines in which French and German stockholders were interested, M. Duval was called upon to furnish a list of such mines. The result is sufficiently interesting to bear publication at this time, and it will be found interesting to those who have thought that it is "perfidious Albion" only who is endeavouring to get at the gold of South Africa.

M. Duval's list is appended, these being the mines selected as having sufficient French and German capital invested in them to warrant the Transvaal government in especially favouring them.

West Rand Mines, France and Germany.

York, Germany.

Violet, France and Germany.

Lancaster, Germany.

Lancaster West, Germany.

Champs d'Or, France.

French Rand, nearly all in France.

Roodepoort United Main Reef, Germany.

Princess Estate, Germany.

Durban Roodepoort Deep, France.

Roodepoort Central Deep, Germany.

Main Reef Consolidated Mines, France and Germany.

Bantjes, France and Germany.

Paarl Central, France.

Langlaagte Estate, France and Germany.

Langlaagte United, France.

Crown Deep, France.

Salisbury, France and Germany.

Jubilee, France.

City and Suburban, France and Germany.

Meyer and Charlton, Germany.

George Goch, Germany.

Henry Nourse, France and Germany.

Jumpers Deep, France.

Geldenhuis Estate, France and Germany.

Simmer and Jack, France and Germany.

Rose Deep, France and Germany.

Glen Deep, France and Germany.

May Consolidated, France and Germany.

New Primrose, France and Germany.

Witwatersrand, Germany.
Glencairn, Germany.
Ginsberg, Germany.
Branches of the East Rand, France and Germany.
New Kleinfontein, France and Germany.
New Modderfontein, France and Germany.
Van Ryn, France and Germany.
New Chimes, Germany.
Nigel, France and Germany.

* * *

The important phase of the Isthmian canal question is the apparent determination of the United States to rush blindly into an espousal of the Nicaragua project. The blindness is wilful, for the comparatively brief delay involved in waiting for the report of the Commission now at work on the Isthmus would give clear and abundant light on the whole question. It is hardly possible to resist the conclusion that the chauvinist element, aided by the mysterious pro-Nicaraguan influences so long working on the Congress, are determined to force action before the light is turned on. Perhaps it would be nearer to the truth to reverse the relations of the factions, and to say the pro-Nicaraguan influence, aided by the chauvinism which has been taught to chant, "I believe in the Nicaragua canal" as the first article of its creed.

And at present all that can be said is that facts as to the Nicaragua canal are not in possession—sufficient facts, at least, to warrant the undertaking to build the canal. Still less do they warrant adhesion to it and curt rejection of a half-completed project which the highest authorities have pronounced perfectly practicable and sufficient, and concerning which the completeness of the information and the elaborate study is nothing less than magnificent.

It is, of course, conceivable that the merits of the Nicaragua route would be so commanding as to make it advisable to abandon the work done on the other line, and begin anew. The reports of former commissions do not make this appear likely, but surely an open mind and an uncommitted judgment should be reserved until the data for a full comparison are obtained. THE ENGINEERING MAGAZINE stands, as it has always stood, simply as an urgent advocate for an examination of all the facts and the formation of an intelligent and impartial judgment.

* * *

A correspondent, with kindly concern, writes us regarding the extremely interesting map of the Panama canal which formed a supplement to our last issue. He suggests that we "have undoubtedly received numerous intimations from subscribers that this map is completely reversed," and, for his part, trusts "that this will be corrected, and he will receive a new map."

None of the suggested intimations has as yet reached us. Probably our friend, who is a Canadian, has been so accustomed to think of the Pacific Ocean as being to the westward and the Atlantic Ocean to the eastward that he looked no further. We trust that reference to any moderate-scale map will assure him that the curious upward bend in the Isthmus brings the oceans into the positions shown; that in going from Colon, on the Atlantic, to Panama, on the Pacific, via the Panama canal, one actually travels southeast—in short, that the map is correct.

REVIEW OF THE BRITISH PRESS

British Shipbuilding in 1899.

IN reviewing the progress of shipbuilding and marine engineering during 1899, *Engineering* gives some interesting and valuable data concerning what is undoubtedly one of the most important engineering industries of the United Kingdom.

There are several salient points about the shipbuilding of the past year which are interesting. In the first place, the "boom" has continued, the total for the year being 1,753,757 tons floated, an excess of 82,000 tons over the preceding year. In the second place this demand has been maintained in the face of the greatly increased prices due to high rate of wages and increased cost of material. Still more encouraging is the fact that by far the greater part of the output has been for the demands of the regular trade; the orders coming from the large companies who have recognized the need for modern ships of great size. Speculative orders for tramp steamers have formed a subordinate feature in the year's work, and the great bulk of the work has resulted from a healthful growth of legitimate demands of increasing business.

The size of vessels continues to increase, 61 of the steamers launched being more than 6,000 tons gross, the great majority of them being over 8,000 tons, and among them being included the Oceanic, of 17,274 tons, the Saxonia and Ivernia of 15,000 tons, the Saxon of 12,970 tons, and the Bavarian, of 10,376 tons.

The total number of vessels built during the year is given as 1,299, as compared with 1,211 in the preceding year. This includes small and great, 864 being under 500 tons, but these do not make more than 8 per cent. of the entire tonnage, and those vessels which may be classed as deep-sea traders make up more than 1,600,000 tons, this giving an indication of the immense importance of the industry.

When the production of past years is plotted in the form of a diagram the progress will be seen to have a general upward tendency, interrupted by sudden drops, the recovery after each period of depression carrying the curve to a still higher point than any previously attained. These drops occur at almost regular intervals of 8 years, and as the last was in 1893, the next might be expected in due course by the first or second year of the century. The points of depression, however, may also be connected with corresponding periods in general business, and it hardly seems logical to assume that there is any especial law affecting the shipbuilding industry alone. Competition, however, has arisen to a marked extent in Germany, being fostered not only by liberal mail allowances, but also by the enthusiasm which has done so much to advance engineering work in all directions in Germany. American competition has not entered the field yet, but is awaiting favourable legislation, but in the ordinary cycles of commerce a cessation of the present great activity must be expected, and there is no better time to prepare for a period of depression than at a season of prosperity like the present.

So far as the building of warships is concerned, the tonnage was slightly less than in the preceding year, being 169,492 tons, as against 193,353 tons, but the value was nearly £600,000 greater in 1899 than in 1898. The warship tonnage for the British Navy was about equally divided between dockyards and private yards, and there were more than 47,000 tons of warships built for foreign countries, while at the same time the dockyards were largely occupied in repair works and in preparing ships for commission. Naval ships, however, form only about 10 per cent. of the total tonnage, and hence the greatest commercial interest is in the development of the merchant marine.

One of the strongest evidences of the growth of foreign competition is found in the gradual decline in the proportion of foreign tonnage. During 1899 21.18 per cent. of the tonnage was for foreign owners, as compared with 24.4 per cent. in 1898, and 30 per cent. in 1896, and while this is evidence that British builders still supply a large por-

tion of foreign trade, yet it shows that the falling off in foreign orders which commenced in 1896 still continues. This is likely to be still further the case in the present year, because a large portion of the present foreign trade comes from Germany, the country which is actively engaged in developing her own shipbuilding facilities and making every effort to retain the orders of her own people, so that further inroads may be expected.

An interesting feature in marine engineering is the proportionally higher powering of recently built vessels.

"The total horse-power of the marine machinery produced during the year is 1,540,814 indicated horse-power, which is 108,000 more than in the previous year, and works out to about 0.9 indicated horse-power per ton of steam vessels built. This is much higher than in the previous year; the explanation is only partly to be found in the number of warships included with horse-power disproportionate to tonnage, for this year there have not been an increased number of such high-powered craft as destroyers, nor have there been more engines built for old steamers or for steamers built abroad. There have been more vessels of the intermediate type, with 15 knot speed, and more also of the first-class liners. Amongst the latter the Oceanic takes first place in this, as well as in respect to speed, and here it is interesting to note that for the first time we have her horse-power stated by her builders, an interesting fact. With 27,000 indicated horse-power for a gross tonnage of 17,274, she has 1.56 horse-power per ton, while 2 horse-power per ton is the proportion in several of her competitors, the Kaiser Wilhelm der Grosse, Campania, and Lucania, St. Louis and St. Paul and the Paris and New York, but it should be remembered that her great length alone is an element which must increase the propulsive efficiency of each unit of power."

An interesting list is given of the output of a number of the leading yards, for which the interested reader is referred to the original article. An idea of the increase in large steamers may be obtained, however, from the fact that while Messrs. Harland & Wolff head the list with an output for the year of 82,634 tons, this includes only seven steamers.

Modern Water-Meters.

THERE is at the present time a general feeling among engineers that the old-fashioned system, or rather lack of system, of estimating water rates by the size of the connection, by the number of faucets, or by the property valuation, should be superseded by the more rational and scientific method of direct measurement. Some opposition which has arisen to the introduction of water-meters is due to ignorance, and to a poorly concealed feeling that behind it is some deep-laid plot to tax the consumer at the expense of health and comfort, a feeling that has been worked upon by unscrupulous and cunning demagogues in numerous instances. Practical experience has shown beyond a doubt that the actual consequence of the introduction of water-meters is a great reduction in waste and in the reckless neglect of proper care of appliances by a limited number of consumers, and a corresponding economy to the great majority of householders who had been previously carrying the burden of others.

The chief element in the proper use of meters lies in the selection of the meter for the work which it is to perform, and in this connection a paper presented before the Institution of Mechanical Engineers by Mr. William Schönheyder, upon the subject of water meters of the present day, with especial reference to small flows and waste in dribbles, is of much interest and value.

Mr. Schönheyder begins by discussing the various classes of meters, subdividing them as follows:

1. Low-Pressure Meters.
2. Inferential Meters.
3. Volume or Capacity Meters, without device for rendering them tight.
4. Those of the Venturi class, which have a special function.
5. Waste-detection Meters, of the Deacon class.
6. Positive Meters, or Meters which provide a space to be filled with and emptied of water, and which have some contrivance for rendering them tight, at varying pressures and under diverse conditions of service.

Each of these classes has its proper function and application and the exercise of judgment only is necessary in order to obtain satisfactory results with the appliances now to be had.

Low-pressure meters, while very accurate, have but limited use, as the entire head of water is absorbed in the passage, and it is therefore necessary to place the meter at a sufficient elevation above the points where the water is to be used to permit a proper delivery after the water has passed the meter. They are of the bucket or drum type, and measure dribbles as accurately as larger flows.

Inferential meters do not measure the flow directly, but act by causing the water to operate a fan or turbine placed in the current, the relation between the speed of revolution of the turbine and the flow being determined by calibration.

Volume, or capacity meters aim to measure the entire flow passing through them, but while consisting of water motors driven by the water passing through them, they have no provision for taking up wear or maintaining tightness, and hence it is possible for small flows to dribble through without being measured at all. They are accurate when new and when operated close to their full capacity.

The Venturi meter operates by measuring the difference of head at various points on a contracted pipe, and while unsuitable for domestic purposes, it is valuable and accurate for a station meter when operated at its full capacity, especially as it is provided with an excellent recording device.

Waste detection meters, of which the Deacon is a type, are also valuable for special purposes, furnishing a record of the flow through mains for definite periods.

Positive meters are naturally those which appeal to the engineer, and many attempts have been made to produce accurate and reliable meters of this type. Nearly all of them are piston water motors, the valve of one piston being operated by the other, there being some mechanical connection between the pistons to compel a uniform length of stroke. Mr. Schönheyder illustrates a large number of such machines, including the three-cylinder meter of his own design, and gives a number of trials to show the limits of accuracy of such devices.

It is undoubtedly correct that a meter for domestic service should measure irregular dribbles accurately, since such wastes constitute a large proportion of the whole, and this can only be done by a positive meter with tight moving parts. The mechanical features to be attained, therefore, are the use of a few working parts with tight packing, yet free from much friction, positively operated by the smallest quantity of water which can enter; and these points must not only be secured in the new device, but they must be maintained during long periods of service without repair or attention.

Such results have doubtless been attained in practice and can be attained continuously, but it must be by the use of apparatus intelligently designed to meet the conditions of actual service by engineers who appreciate the nature of the problem.

The Standardisation of Screw Threads.

THERE is little or no difference of opinion amongst engineers at the present time about the desirability of the unification of screw threads, although when the pioneer system of Whitworth was introduced, in the period between 1841 and 1860, many manufacturers seriously held to the view that by using a peculiar form of thread they were retaining to themselves the trade and repair work of their customers which they might otherwise lose.

At the present time there is little or no such narrowness of view, and the general introduction of standard screw-cutting devices in all parts of the world has rendered it practically necessary for builders of machinery of all kinds to use screw threads which can be matched by commercial bolts and nuts on the open market.

In view of the question of a standard system of screw threads for use in the metric system of measurements *Engineering* publishes a review of the whole subject of standardisation of screw threads, based largely upon a paper communicated to the Turin Society of Engineers and Architects by Signor Galassini, one of the Italian representatives at the Zürich International Screw Thread Congress; and the timeliness of the matter renders a discussion of the subject appropriate at present.

Whitworth's system was in general use in Great Britain by 1861, and has so remained, while in the United States the Sellers, or Franklin Institute, standard, came out in 1864, and so came into general use before the Whitworth system secured a

permanent foothold there. So long as the metric-using countries purchased a large proportion of their machinery from England the Whitworth system remained standard over the greater part of continental Europe, as well as in other parts of the world to which British machinery was exported, but at the same time there has been a constant and persistent effort to introduce a standard metric screw-thread system, and with the development of machinery construction in Germany, Belgium, Switzerland, and other metric-using countries, the need of a suitable screw-thread system has become more and more pressing.

As might have been expected, the efforts of a number of independent individuals, organisations, and governments to attack such a problem without some plan for concerted action, has led to the production of a great number of systems, many of them differing but slightly from each other, and no one of them having come into anything like general use. The consequence is that at the present time we see in Germany, Switzerland, Belgium and other countries in which machine building has developed, the curious fact that tools, engines, and general machinery are designed with all parts dimensioned in the metric system with the exception of the bolts and nuts, these being dimensioned in inches and vulgar fractions thereof, and with screw threads formed upon the standard Whitworth system.

The great difficulty in the way of the adoption of a metric system appears to lie in the very number of proposed systems, and in the unwillingness of the various countries, organisations, and individuals to enter into any agreement as to the system to be adopted or as to the method of securing its adoption.

Within the last few years, however, it seems to have dawned upon those who have interested themselves in the problem, that what was really needed was, not a new screw-thread system, but some responsible organization which could command sufficient international influence to effect the adoption of a definite system into general practice. It has been fully demonstrated that this could not be effected by any national engineering society, since one country would always be unwilling to accept a standard urged by an organisation of another country, probably both a political and commercial rival, and the same feeling prevented the general acceptance of the action of any single government, however judicious or desirable.

The organisation of the International Screw Thread Congress, however, seems to be a recognition of the fact that the true method of accomplishing something has at last been appreciated, and this is further confirmed by the use of a country like Switzerland, unimportant politically, altogether neutral and free from international complications, and at the same time prominent mechanically, as a location for meetings and a basis for action.

At its last meeting in Zürich the congress practically accepted the Sauvage system, already largely used in France, making some slight modifications which serve to make it nominally the system of the International Congress, and postponing further action until a later meeting at Berne in connection with the International Congress for Railway Unification.

It is in the formulation of a metric screw-thread system that the weak feature of the metric system itself appears most distinctly. The subdivision by tenths often causes too wide a leap to be satisfactory, and a disposition to fall back upon the system of halving and quartering persists in cropping out, just as the market people in France continue to use the half and quarter litre and kilogramme, ignoring the decimal idea altogether. Of course it is evident that the decimal system may be and is used to express these values, but the use of pitches such as 1.25, 1.50, and 1.75 millimetres shows the convenience of the system of continual bisection in the formation of a series in a manner which is but thinly concealed.

The outcome of these later efforts will probably be the general adoption throughout the mechanical world of three main screw-thread systems, the Whitworth, the Sellers, and the International Metric, while as *Engineering* suggests, the demand for a fine-thread system for such work as watchmaking, the construction of mathematical instruments, and the like, will probably be filled by the Thury system, based on the

metric units of measurements and devised especially for this class of work.

Ultimately the general adoption of the metric system is expected to cause the disappearance of all screw-thread systems based upon the inch, but the accomplishment of that result is probably a long way distant, and screw-cutting machinery built in England and America for use in countries where the metric system is in use will continue to be made, as now, with change gears enabling threads in either system to be made with as high a degree of precision as the relation between the two systems is practically known.

Electrolytic Copper Tubes.

WITH the increase in steam pressures and consequent increase in temperatures the demand for seamless copper tubing for steam connections and similar purposes has led to various attempts to produce tubes of any required diameter without the necessity of using brazed seams. Among these it is but natural that the idea of employing electrically-deposited copper should have been considered, and so long ago as 1876 experiments were made in Russia, the land where the electro-deposition of metals originated, and tubing of moderate dimensions successfully produced. The principal difficulty in practice appears to have been the granular character of the deposit, thus causing its strength to be irregular, and frequently far below that of the rolled metal, and recent efforts have been mainly directed toward the development of some method by which pure fibrous copper of maximum strength may be deposited electrically even when a high current density is employed.

Various plans have been tried to obtain a uniform and tough deposit of copper, and in a paper recently presented before the Institution of Electrical Engineers, Mr. Sherard Cowper-Coles reviews these, and describes the centrifugal method, devised by himself. The well-known Elmore process employs an agate burnisher for the purpose of consolidating the copper during deposition. When this method is used for making tubes the cathode on which the copper is deposited is slowly revolved while the burnisher traverses back and forth, producing a copper of high density, the specific gravity being as high as 9.2, and the strength 26.5 tons per square inch. The principal drawback to this process is the tendency of the copper to exfoliate under the burnisher, the pressure requiring to be regulated to a great nicety. Another method employs a sheep-skin burnisher instead of a metal one, the effect being to cover all projecting parts with a thin film of animal fat, which hinders further deposition until the surrounding depressions have been raised to the common level. Various other forms of impregnators have been employed for a similar purpose. Other methods have been devised in which the electrolyte is injected upon the copper during deposition, but none of these has as yet come into extended use.

In the centrifugal method, devised by Mr. Cowpes-Coles, no burnishing is used, but the mandrel is caused to revolve at a high rate of speed, while the copper is being deposited upon it. Several results are produced by this action. The skin friction between the deposited metal and the electrolyte keeps the copper smooth and compact, and at the same time any gas bubbles evolved at the cathode, or any impurities in mechanical suspension in the electrolyte, are thrown off by centrifugal force, and hence the principal sources of defects are removed. Porosity is largely due to the formation of gas bubbles, while excresences are mainly due to the presence of specks of foreign particles. In addition to the revolving motion which is given to the mandrel, the electrolyte is briskly circulated through the cells by an acid-proof pump, the solution being forced or pumped to a reservoir, where it is passed through a filter to rid it of all impurities in suspension.

By the employment of this method it has been found possible to produce smooth and tough deposits with the remarkably high current density of 190 amperes per square foot, the voltage being about 1 to 1.2. It is also practicable to use a hot and more acid solution than has generally been employed, this allowing a heavier current to pass at a much lower voltage than would otherwise be possible, the deposit also being much tougher than when a cold solution is used. Some copper sheet, not annealed, deposited by the centrifugal process, 0.0245 inch in thickness, broke at 433 pounds, which is equal to 22.1 tons per square inch. Hard-

drawn wire made by this process has a tensile strength of 29 tons per square inch, the electrical conductivity being 99 per cent.

It is rather interesting to note that formerly copper pipes were made by bending and brazing rolled sheet copper, while at the present time it is found desirable to produce sheet copper by electrolytically depositing a seamless tube and subsequently cutting it open and flattening it out.

The development of this branch of electrometallurgy is an excellent instance of the manner in which electrical processes are modifying and in some cases revolutionizing older methods. It is authoritatively stated that more than one-third of the copper produced in the world is now electrolytically refined, one-half of the output of the United States being so produced, and nearly all the copper used by electrical engineers is refined electrolytically.

Multiple Expansion Engines.

THE questions of cylinder ratios, points of cut-off, and receiver-drop have been discussed and re-discussed many times over without resulting in any definite solution of the several involved problems, and it is therefore with mingled feelings of interest and distrust that the paper of Professor R. L. Weighton before the North East Coast Institute of Engineers and Shipbuilders upon receiver-drop in multiple expansion engines is received. The paper itself handles the subject in a thoroughly careful and satisfactory manner, and details the results of trials upon an experimental engine well adapted for the purpose, and the conclusions were undoubtedly warranted by the results in the particular cases under consideration. The extent to which those conclusions are applicable to widely differing conditions remains to be seen.

The real object of the experiments was the determination of the most economical point of cut-off in the larger cylinders of multiple-expansion engines—that is, in the low-pressure cylinder of compound engines, in the intermediate and low-pressure triple expansion, and in the two intermediate and low-pressure cylinders of quadruple expansion engines. At the same time it was endeavored to determine that receiver drop between any two cylinders with which was associated the maximum degree of economy, as well as the general effects of varying amounts of receiver drop.

It is impossible here to go into the details of the trials, which were very exhaustive and which are fully described in the paper. The results are fully tabulated and also plotted in the form of curves showing the water used per hour, the brake horse-power, and the water used per brake horse-power per hour. Combined indicator diagrams for the three cylinders of the triple expansion engine are also given for various points of cut-off, thus showing the effect of varying the cut-off in the intermediate and low-pressure cylinders upon the drop, and from the data and results thus exhibited Professor Weighton deduces his conclusions.

The first and most important of these conclusions is that the one and only factor which affects materially the cut-off of maximum economy in any one of the cylinders following the high-pressure cylinder, is the ratio between the cylinder in question and the immediately preceding cylinder. In other words, the ratio between any two successive cylinders is the one factor which determines the point of maximum economy cut-off in the second of the two cylinders. This relation is expressed as follows:

$$\frac{\text{Maximum-economy cut-off}}{\text{stroke}} = \frac{R + 6.6}{6.6\,R}$$

From this it follows that the cut-off in the larger cylinders, once fixed should never be altered, whatever may be the cut-off in the high pressure cylinder, or the steam pressure employed; and automatic expansion governors, or linking-up gear should act upon the high-pressure cylinder only, if maximum economy at all powers is to be preserved.

The effect of cut-off in the larger cylinders upon total horse-power is also to be considered, and the experiments revealed a peculiar relation in this respect. As regards the low-pressure cylinder of triples, and the second intermediate and low-pressure cylinders of quadruples, maximum power cut-off in these cylinders coincides with the cut-off of maximum economy as determined by the above formula. As regards the second cylinder of triples and quadruples, maximum-power cut-off is very considerably later than that of maximum economy. A considerable variation in cut-off does not materially affect the economy,

however, when the cylinder ratio is small, but when R is large there is no such permissible deviation without a consequent fall in efficiency.

Should these simple relations be found to hold good for engines widely different from those upon which Professor Weighton made his experiments the proportioning of multiple expansion engines will be greatly simplified. There will, however, doubtless be much discussion, and we trust many further experiments, upon the questions which have thus again been raised.

Waste Water from Factories.

ALTHOUGH much of the pollution of streams is due to the discharge of sewage the great difficulty in some localities lies in the large quantity of factory waste which must find an outlet, and which is altogether objectionable in rivers. Following out the general idea of prevention now so successfully adopted for dealing with sewage pollution, the subject of the purification of trade waste water was discussed at a recent meeting of the Institution of Civil Engineers in papers by Mr. Reginald A. Tatton and by Mr. W. O. E. Meade-King, of which an abstract is here given.

The method of purification naturally differs according to the character of the waste, and in most cases the purification may be combined with such an extent of waste-recovery as to be desirable from an economical point of view, apart from the importance of abating a nuisance. Three examples cited by Mr. Tatton will serve to show the methods which have proved satisfactory in actual practice for dealing with the particularly objectionable discharges from dye houses and wool scouring factories.

In the case of ordinary bleaching, dyeing, and finishing, it has been found that precipitation with lime and iron-alum, followed by filtration through cinder, effected a satisfactory purification. At an establishment discharging about 500,000 gallons of such waste per day two series of settling tanks were used, the greater part of the suspended matter being deposited in the first series upon the addition of lime and iron-alum, and a final settling taking place in the second series. The liquor from the tanks was clear and free from suspended matter, and the final passage through the cinder filters rendered the effluent apparently unobjectionable.

The waste water from wool-scouring is of a very polluting character, owing to the amount of grease and animal matter extracted from the wool in combination with soapy matter, and it is found desirable to keep the greasy water separate from the dye waste, in order that separate treatment may be given. The solids from the greasy water are successfully precipitated by the use of lime and ferric chloride and settled in a series of three tanks, the sludge being collected on filters of cocoanut matting, and after partial drying the oil extracted in presses, the water from the filters being discharged into the stream.

When the wastes are from the processes of calico printing, dyeing, and bleaching, the pollution is caused by alizarine, logwood, and other dyes, and by soap, starch, etc. In such cases a main settling tank of large capacity is used, from which the waste can be pumped into two precipitation tanks alternately, iron-alum being used as a precipitant. The sludge from the tanks is pumped to a sludge drying area, and the water filtered through fine ashes.

Where the water contains much dyestuffs and soap the recovery of the wastes is an important matter of economy, and it is often found better to keep the concentrated logwood liquor separate for treatment by itself.

In the case of waters from breweries and tanneries, precipitation should be followed by effective filtration or land treatment, if it is impracticable for the waste to be discharged into the sewers.

The question of cost is an important one in connection with the purification of trade wastes, and the use of salt as an aid to rapid precipitation was suggested by Mr. Meade-King. The use of rapid filtration plants was also a matter for discussion, the limited area available for putting down filtration plants often being a controlling consideration. If the material of the filter bed be so chosen as to afford a free and rapid passage while at the same time exposing the effluent to extended contact with the air for oxidation it might be possible to treat within a limited area a quantity of waste otherwise unmanageable.

The experience which, it is shown by these papers, has been gained in the treatment of trade wastes is sufficient to render it altogether apparent that there is no good reason why such wastes should be permitted to pass in their raw condition into streams to create a nuisance by pollution, and possibly endanger the health of the community. The fact that in most cases the recovered wastes possess a distinct value should aid in the enforcement of effective purification methods.

Ventilation Without Draughts.

NOTWITHSTANDING the various treatises which have been written upon the subject of ventilation, and the number of eminent engineers who have devoted themselves to this line of work, the fact undoubtedly remains that there are very few buildings which are provided with satisfactory systems of ventilation. We know about how much air is vitiated in a given time by a man or a gas burner, and we know how the vitiated air can be removed and replaced with fresh air, but when it comes to performing this apparently simple operation in practice, we nearly always make a mess of it. Sometimes we try to pull the foul air out expecting the pure air somehow to find its way in; on other occasions we try to push the fresh air in, and expect it to drive the foul air out. In either case we generally succeed in producing uncomfortable draughts and in accomplishing only very imperfectly the complete renovation of the atmosphere of the space under consideration.

In discussing this subject in a paper before the Society of Arts, printed in the *Journal* of the Society, Mr. Arthur Rigg brings out some excellent points, which are well worth reviewing.

After quoting authorities in a number of walks of life to show the necessity of providing better and more adequate ventilation, Mr. Riggs goes on to show how defective some of the most pretentious ventilating schemes have really been. The lecture rooms of the University of Glasgow, the Houses of Parliament, the new Law Courts, all are evidences of failure to accomplish the apparently simple task of providing pure and fresh air for a number of assembled people without at the same time exposing them to injurious draughts. The common method of ventilation is the vacuum system. The ordinary fire place acts to produce a suction up the chimney, and the result is the production of chilling inward draughts under the doors, around the windows, and even through the walls. The same effect is produced in those ordinary cases in which the vacuum is produced by a mechanical means. Especially is this the case when the exhausting apparatus draws the air from the upper part of the room, as is usually the case. Very commonly the area of the inlet openings, when such are provided, is by no means as large as should be the case, and the result is an increased velocity most uncomfortable and even dangerous to those who may be obliged to remain near the air inlets.

Mr. Rigg comes out plainly in favour of the pressure, or plenum system, and believes in forcing the fresh air in rather than in merely sucking the foul air out. In order to accomplish satisfactory ventilation by this system, there are several points which should be carefully considered. In the first place, the general flow of fresh air should be downward. The foul air naturally sinks, except in the limited area where it is highly heated, and it can always best be removed from below. The fresh air should be introduced as an upward current from openings above the heads of the audience, but not so high as the ceiling. It should be delivered in divided streams into the upper part of the room, so as to mix with the warm air already travelling there. Exits for carbonic acid, dust, and watery vapour should be provided at, or near to the floor level, if required. The roof or ceiling of a properly ventilated chamber should be hermetically closed. Open windows should be used only during warm weather, never in winter. Natural draughts cannot always be relied upon, and hence, when necessary, fans, furnaces, or other artificial means should be resorted to.

Mr. Rigg gives a number of examples of faulty ventilation, and shows how, by modification, in accordance with the foregoing principles, and by providing sufficient inlet area to avoid too high velocities, an ample and comfortable ventilation may be secured, while at the same time draughts may be avoided.

REVIEW OF THE CONTINENTAL PRESS

The Problem of Submarine Navigation.

THE interest which is taken at the present time in submarine boats for military purposes is evinced by the discussions which attend any public trials of such craft, and in France especially, the possibilities of such an auxiliary to naval power are at present attracting much attention.

Apart from the detailed construction of any particular boat, there is an interesting discussion of the general principles upon which successful submarine navigation must depend, appearing recently in *La Revue Technique*, and written by M. H. Noalhat.

While there are a number of special features about submarine navigation which render the problem essentially different from that of navigation at the surface, these may broadly be classified into two main questions; immersion and orientation. In his present paper M. Noalhat confines himself to the examination of the first of these, promising, however, to take up the second in a later contribution.

After enunciating the well-known principle of Archimedes as to the fact that every immersed body is buoyed up by a force equal to the weight of the volume of displaced water, and acting vertically upward at the center of gravity, M. Noalhat proceeds to consider the stability of immersion at various depths, both for a boat at rest and for one in motion. When the buoyancy is just equal to the weight of the boat it may be said to be neutral; when the buoyancy exceeds that of the boat it is positive, and when it is less it is said to be negative.

The control of the depth of immersion of a submarine boat may be based upon one or the other of two conditions; neutral buoyancy or positive buoyancy.

In the case of neutral buoyancy, the weight and the lifting force being equal, the boat theoretically remains submerged at a given depth. This theoretical condition is not completely attainable in practice, although it has been attempted many times. It is very difficult to secure exact equality between the weight and the buoyancy, and such an equilibrium, even if attained, would be disturbed by submarine currents, by variations in atmospheric pressure, and by other uncontrollable factors. The nearest approach which can be made to neutral equilibrium in practice is secured by providing a means of quickly and readily varying the weight of the boat, itself already very near a state of neutral buoyancy, thus permitting an immediate correction of any tendency to sink or rise as such may appear.

This system naturally involves the use of some variable ballast, in practice a water-ballast, which may be controlled by pumps, and some very ingenious devices have been invented for regulating the action of the pumps by the external pressure, thus causing the depth of immersion to be automatically maintained within moderate limits. The principal difficulty with such a system is found in the fact that all such devices require an appreciable time to respond to the control, and as the boat must start to sink or to rise before the pumps receive the corrective impulse, and as a still further lapse of time is necessary before a change in the ballast sufficient to affect the equilibrium is produced, the range of rise and fall may become altogether too great to be satisfactory or even safe.

When this system is applied to the regulation of the depth of immersion of a boat in motion the tardiness of response affects very materially the angle of descent or ascent, and in practice it has been found successful unassisted only when used at very moderate speeds.

The second method, that involving positive buoyancy, has been employed in a number of cases. It depends upon the provision of an excess of buoyancy, causing the boat to have a constant tendency to rise, this tendency being opposed by mechanical devices in order to enable immersion to be produced at will. This method appeals to all designers, because it possesses the valuable feature of causing the boat to rise to

the surface in case of any failure of the machinery. It also gives opportunity for the introduction of devices for maintaining stability mechanically.

Various devices have been employed to produce and control immersion in boats of this type. Screw propellers on vertical axes, first tried by Bushnell in 1773, have been employed many times since; Waddington having used two screws, placed in wells situated fore and aft, while Nordenfelt placed the screws on each side. The principal trouble encountered with such devices in practice lies in the difficulty of obtaining uniform action of the two screws, the slightest preponderance of one or the other being sufficient to destroy the equilibrium of the boat.

Another method of controlling such a boat is the use of horizontal rudders, such rudders having first been used in a rudimentary fashion in 1809, by the brothers Coessin, and since 1872, in various types of automobile torpedoes. In some cases a single rudder, placed at the stern, is used, but horizontal rudders placed on each side have been found effective, these all involving a progressive motion of the boat.

The great difficulty with all methods of controlling the position of a submarine boat is that of maintaining a horizontal position, most of the plans causing a descending and ascending motion, the boat thus being generally at more or less of an angle with the horizontal. Such boats are also necessarily liable to have their equilibrium disturbed by movements within, and any shifting of weights, such as the handling of torpedoes, or much movement of occupants, may produce a perceptible effect.

In view of the experience which has been had with modern boats, there is every reason to believe that the principle of positive buoyancy, united with effective mechanical means for producing submergence, is the correct one, and when combined with a satisfactory method of orientation, or control of lateral direction, will be found superior to the older method of neutral equilibrium.

M. Noalhat's paper will be found an instructive study in connection with one of the most practical problems of modern marine science, and it is to be hoped that he will continue his further presentation of it.

Gas Power for Electric Stations.

THE development of the gas engine and the application of lean and cheap gas to motive-power purposes have both led to a widening use of gas power, and from being little more than a toy, driving job presses or turning ice-cream freezers, the gas engine has in many instances become a worthy rival of the steam engine.

The possible advantages of gas as a means of power transmission are discussed in a leading article elsewhere in this issue, and the general application of the gas engine as a motive power for electric generators forms the subject of a paper before the Hanover Electrotechnical Society, by Herr M. Krone, published in the *Zeitschrift des Vereines deutscher Ingenieure*, in which an account of the working installation at Clausthal is given.

In order to compare the operating cost of steam and gas power Herr Krone gives a computation for the cost of steam power, both with and without condensation, including interest on cost of plant, depreciation, and attendance; this estimate including also the cost of the electric plant for an installation of 100 horse power, with an equal amount as reserve. Taking all the charges into account, Herr Krone shows the cost of an electrical horse-power-hour delivered to the distributing system is, for a non-condensing engine 10.85 pfennig, or with condensation 9.97 pfennig, or for a year of 3,109 hours the cost works out, for the condensing plant, £15 10s., or about $74 per electrical h.p. per annum.

The economy to be effected by the use of gas only affects the fuel portion of the charge, since the cost of the installation, attendance, depreciation, and other fixed charges do not materially differ in the two plants, the cost of installation of the gas generators offsetting the cost of boilers to a large extent, and the difference being made up by the increased cost of the gas engines.

Making the computation on precisely the same basis as that adopted for the steam plant, the cost of an electrical horse-power-hour comes out 8.22 pfennigs, which corresponds to £12 15s., or $61.80 per horse-power per annum; gas thus showing an economy of 16.2 per cent. over steam power.

The gas power plant at Clausthal, of

which a detailed account is given, was constructed in 1897 for lighting the adjoining towns of Clausthal and Zellerfeld, having together 13,500 inhabitants, and its moderate size and excellent performance show the adaptability of this system to small electrical plants.

There are at Clausthal two gas generators of 100 h.p. each, these consisting of sheet-iron cylinders lined with fire-brick and provided with grates at the bottom, and with feeding funnels and cones at the top. Steam is furnished by small auxiliary boilers, and used in jet blowers delivering air beneath the grates, the fuel being burned to carbonic oxide, with such a proportion of water gas as is due to the steam passing through the jet blowers. The gas is passed through condensers, scrubbers, and purifiers, and delivered to a holder, from whence it is drawn by the engines.

There are two Körting gas engines of 70 h.p. each, operating normally at 140 revolutions per minute, but this speed can be increased about 15 per cent. when it is desired to charge the storage battery.

There is no especial feature in the construction of the gas engines worthy of remark except that the regulation is effected, not on the hit-and-miss system, nor by varying the proportions of the explosive mixture, but by varying the amount of the charge, the mixture remaining constant. Experience has demonstrated that a variation of 50 per cent. in the load produces less than 3 per cent. variation of speed, a regulation which places the gas engine in the same rank as the steam engine, so far as governing is concerned.

The electric generators are of the continuous-current type, also built by Körting, and are directly connected to the engine-shafts. The dynamos are each of 46 kilowatts capacity, the three-wire system being used with an operative pressure of 110 volts, the dynamos being operated at 240 to 345 volts.

The working economy of the plant is shown by the data for the year ending in March, 1899, the average output being 707 watt-hours per kilogramme of fuel, which corresponds to 2.32 pounds of mixed coke and anthracite per electrical horse power delivered to the circuit. This performance has doubtless been surpassed in certain steam plants, but only when operated on a far larger scale, and when the size of the plant is considered this result is certainly excellent.

The experience which has lately been gained in connection with the construction and operation of gas engines of more than 600 h.p. capacity should lead to a careful investigation of the advantages of gas power for electric plants before a final decision is reached, and in certain localities, at least, it may frequently be found more desirable to employ gas than steam.

Corrosion in Steam Boilers.

MUCH attention has been given to the subject of incrustation of steam boilers, and the properties of various feed waters, so far as the formation of scale is concerned, have been extensively discussed. The question of corrosion, however, is sometimes a matter of more consequence than that of the formation of scale, and waters which may be very suitable for boiler feed as regards scale, may still be altogether unsuitable when their action upon the metal is taken into account. This side of the question is discussed very thoroughly in a series of papers in *Le Génie Civil* by M. H. de la Coux, and from his examination, some points of much practical interest may be abstracted.

Pure water, and water containing carbonic acid, such as rain water, are powerful solvents, as will at once be seen when it is remembered that the rain, falling upon the surface of the earth and percolating through the various strata, comes out into the springs and rivers more or less highly charged with solutions of the materials through which it has passed, although many of these are but slightly soluble. In the presence of oxygen and of carbonic acid iron is powerfully attacked by water, ferric hydrate and ferrous carbonate being formed, both being subsequently converted into ferric oxide.

All waters are corrosive, but in different degrees, according to the nature of the substances which they hold in solution. These substances may be gaseous or may be solids in solution, which either when deposited as scale or by decomposition in solution, release free acids which attack the metal of the boiler.

Waters containing only gaseous corrosives

may generally be purified by boiling, and those containing free acids, such as is the case with water from many mines, may frequently be neutralised, but the waters which M. de la Coux has classified as "incrusto-corrosive" require treatment varying with the nature of the dissolved substances.

The principal acids which are apt to appear and attack the interior of a steam boiler are hydrochloric acid and sulphuric acid. Most of the chlorides which are found in feed waters are too stable to undergo decomposition and liberate free acid; the exception is chloride of magnesium, which is readily decomposed by heat, oxide of magnesium being thrown down and hydrochloric acid set free to corrode the boiler. Chloride of ammonium, which may occur in waters containing organic matter, is also very unstable, and readily releases hydrochloric acid in the heat of the boiler. Chlorides of calcium and sodium are much less active, but are by no means permanent, and especially in the presence of other substances, may give rise to energetic corrosive action.

The compounds of sulphuric acid may under certain circumstances give rise to active corrosion. Ferrous sulphate alone produces no action, but in the presence of oxygen it becomes partially converted into ferric sulphate, which is itself corrosive and which also forms a basic ferric sulphate with the liberation of sulphuric acid, which latter attacks the iron of the boiler to form fresh ferrous sulphate, renewing and continuing the process. In certain localities where the water is taken from argillaceous soils it is found to contain aluminum sulphate, which behaves in the boiler in a similar manner to the ferric sulphate, so that water from such localities must be used with caution. Sulphate of copper is also found in many mine waters, and this in the presence of iron is decomposed with an exchange of the two metals, forming a soluble salt of iron with all the corrosive properties above noted.

Among the salts which are most detrimental to the durability of steam boilers the nitrates demand careful attention. Although they occur in but small quantities they are so readily decomposed by heat as to be very injurious. Ferric nitrate especially is readily decomposed into a basic nitrate and free nitric acid, which produces a deep corrosion of the plates of the boiler, forming ferrous nitrate, which passes to ferric nitrate to renew the decomposition continuously. Finally the presence of sulphuretted hydrogen, due to the decomposition of organic matter in the water, may give rise to serious corrosion, becoming oxidised to sulphuric acid in the presence of free oxygen.

M. de la Coux devotes some attention to the nature of boiler corrosion, showing that there are two distinct kinds of action, one in which isolated cavities or pustules are formed in the metal, and the other in which extended surfaces are eaten away.

From the frequent presence of calcium carbonate in the isolated cavities, some engineers have concluded that this form of corrosion was not due to the direct action of an acid, because an acid could not exist in the presence of the carbonate. A careful examination of the contents of such cavities, however, has revealed the distinct presence of acid reactions, so that no such positive conclusion can be drawn. Corrosion in isolated cavities, however, is generally produced by water charged with carbonates, liberating carbonic acid in the presence of oxygen. When an extended surface of corrosion is found it has generally occurred beneath a coating of scale, the corrosive substance having been imprisoned in the mass of the scale, this action being the more dangerous because it is not apparent upon inspection.

M. de la Coux goes into a careful examination of the behaviour of mine waters and of sea water, showing in the latter case the effect of the concentration of chloride of sodium upon the solubility of the other salts. Although the density of the salt in a marine boiler may be kept below a determined point by the use of the salinometer and by frequent blowing-off, it must not be assumed that the deposits of sulphate of calcium or the corrosion due to the sulphate of magnesium are limited thereby.

In examining the possible remedies against corrosion, either from acids or from incrusto-corrosives, M. de la Coux discusses the use of zinc, lime, calcium, carbonate, soda and potash as correctives in various cases, and gives a tabulated view of the various waters which may be found in prac-

tice, with the actions of the corresponding correctives. This table should be consulted in order to understand fully the chemical reactions involved in the various cases, but so far as the action of incrusto-corrosives is concerned the strongest emphasis is laid upon the value of the alkaline carbonates (carbonates of sodium and potassium) and of oxide of barium, not only as preventives of corrosion, but also to act against the formation of scale.

Telegraph Wires on Glaciers.

In a communication to the French Academy published in a recent issue of *Comptes Rendus,* the veteran astronomer, M. Janssen, gives some interesting information as to the insulating power of glacier ice, as developed in the telegraph work conducted in connection with the Mont Blanc observatory during the past year. These investigations were conducted by MM. Lespieau and Cauro, and the unfortunate feature of the work was the fatal accident to M. Cauro almost at the outset of the experiments.

The undertaking upon which the studies were made consisted of the connection by wire of the summit of the mountain with the Grands-Mulets, and the interesting feature of the experiment was the fact that the naked wires were permitted to lie directly upon the surface of the glacier, without any support or insulation.

The wires used were the regular French Government standard of galvanised iron, 3 millimetres in diameter, and the length of the line was about 1,700 metres, or a little over a mile, this being the distance between the terminals, and hence the length of each half of the circuit. The wires were laid directly upon the surface of the ice, being about 5 metres apart, no insulation being used even where they came in contact with the rocks for a few metres at the Grands-Mulets terminal. Having been found to operate satisfactorily with the telegraph instruments, they were tested for resistance and insulation. These measurements showed that the insulation was almost perfect. Galvanometer deflections on the line at points distant 300, 600, and 1,700 metres from the lower station were practically identical with those at the terminal, and the resistance of the line, as tested by a Wheatstone bridge, was found to lie between 56 and 57 ohms, while with perfect insulation it would have been but 59 to 60 ohms, so the loss was insignificant.

The results of these experiments, while perhaps of limited application, may yet prove of much importance in mountain exploration work, since it is shown that telegraph wires may be laid over the ice in the trail of an exploring or military party with but little labour or cost.

One point which must not be overlooked in this connection is the influence of cold upon the battery. The resistance varies notably with the temperature, probably due to the reduction in strength of the chlorhydrate of ammonia caused by deposition of the salt. Down to temperatures not lower than 16° C. the electro-motive force remains practically constant, after which the solution slowly freezes. When the mass has become solid the temperature continues to fall, and the resistance increases enormously. These points must be taken into account, especially in connection with electrical measurements made at low temperatures.

In view of the fact that the surface of a glacier is always in slow motion the permanency of a telegraph line laid upon the surface of the ice cannot be insured. M. Janssen promises some future data upon this point, which must necessarily involve observations made over a considerable period of time, but as such lines will probably be laid only for temporary purposes, this is not a matter of fundamental importance.

Hinged Masonry Arches.

In attempting to arrive at an accurate determination of the true stresses in masonry arches, two difficulties have been encountered: one, the inferiority in resistance of the mortar to that of the stone, and the consequent imperfection of the joints, and the other, the indeterminate position of the line of pressure at the key and at the springing.

If the line of pressure could be compelled to pass through certain points, just as a catenary passes through the points of suspension, the remainder of the curve could be accurately determined for any given span, rise, and loading, but otherwise the problem can only be approximately solved.

In order to enable a closer determination of the conditions existing in masonry arches to be made, the Inspector General of the Ponts et Chaussées, M. Maurice Lévy, has had a series of experiments made upon the use of poured metallic joints in connection with hinges at the key and springings, and the results of these experiments are very fully detailed in a paper in a recent issue of the *Annales des Ponts et Chaussées*, by M. H. Tavernier, from which a brief abstract of the results is here made.

It has been attempted to equalise the pressure upon the joints in masonry arches by placing thin sheets of lead therein, but the results appear to indicate that uniform contact is not attained by that method within the limits of settling and movement necessary to maintain the computed form of the curve. M. Tavernier therefore attempted to fill the joints with melted metal, thus filling the space entirely when the voussoirs were in the exact position desired, and this he appears to have succeeded in accomplishing very satisfactorily. Various metals were tried, the desired conditions being fusibility at a low temperature, combined with hardness and resistance when cold, and these appeared to be best fulfilled by an alloy of the nature of type metal, sufficient lead being used to secure fusibility and fluidity, the hardening being provided by the addition of tin and antimony.

In regard to the action of hinged joints, experiments were made to discover the extent to which friction might prevent the proper action of the hinge under pressures such as obtain in arches of considerable span and moderate rise. These experiments were made at the armor plate works at Saint Chamond, a hinged joint such as has been used in bridge work being placed upon a horizontal support and loaded with pieces of armor plate. Upon the top of the fixed load was placed a movable load of one ton, so placed that it could be rolled into different positions, while pointers attached at the hinge enabled the movement to be observed. This apparatus was tried with loads corresponding to pressures of 5,700, 8,250, 14,200, and 20,000 pounds per square inch of projected area of pin, and coefficients of friction determined for good and for imperfect lubrication, and also for non-lubricated surfaces. The results showed that by placing the centre of the pin a small distance out of the centre of the joint, a leverage corresponding to the resistance of friction could be used to correct for this action and compel the line of pressure to pass through the centre of the joint.

Having determined these points, an experimental arch was constructed at Saint Chamond, having a span of 49 feet and a rise of 2.95 feet, each half of the arch consisting of four voussoirs, with lead joints, the thickness of the voussoirs being 7 inches at the crown and springing, and 9.8 inches at the haunches. As solid abutments were not readily procured, the springings were tied together by rods, there being hinges both at the key and at the springings.

This arch was loaded gradually by direct weighting with pig-iron, the deflections at the joints being measured by multiplying levers, and although the depression of the crown at the instant of rupture was 7 inches for a total rise of only 35.4 inches, there was no sign of breaking or spalling off of stone at the joints, the failure occurring by splitting of the stone practically along the middle line of the curve.

Experiments of this sort undoubtedly add much more to our knowledge of the true action of forces in structures than theorising which may have failed to take some important factor into account, and it is to be hoped that they will be extended to still larger scale examples.

Electric Locomotives in Germany.

WHILE the steam locomotive is the natural development of the necessity of carrying the entire power-house on wheels which is involved in the fundamental idea of independent steam traction, and hence is no proper model to be followed under the wholly different conditions of electric traction, yet in the transition state between steam and electric traction the electric locomotive appears to be an intermediary. For the present, at least, electricity must be used on main lines in connection with steam, and the electric power must be provided in such a form that it can be conveniently substituted for the steam locomotive, and thus the electric locomotive comes in as an auxiliary.

The main reason for employing the electric locomotive in such a connection lies in

the absence of smoke, gas, and noise, and for hauling trains through tunnels, making transfers across cities, or making up trains in the yard, much of the discomfort and nuisance unavoidable with steam can be entirely prevented.

Electric locomotives have come into use for such purposes in Germany to a marked extent, and in a paper presented before the German Society of Mechanical Engineers by Herr A. Tischbein, and published in *Glaser's Annalen* a description is given of a number of instances in which electricity has been found a helpful auxiliary.

When a definite portion of the track is to be used for electric traction, as in the case of tunnels, private sections, train-yards, and the like, the overhead trolley has been found the most convenient method of transmitting the energy, and several such installations are shown in Herr Tischbein's paper. When, however, the electric locomotive is liable to be called upon for service on any part of a railway system, the accumulator type is used, both forms having been successfully used on various German railways. The third-rail system, which has met with successful application in the United States, has not yet been applied in Germany, not being considered applicable for satisfactory use upon lines used also by steam locomotives. In some cases a combined system is employed, accumulators being provided for use when required, while the overhead trolley is used for charging and for use in yards and other places where wires can conveniently be provided.

An example of the combined construction is seen in the locomotive for the Lagerhof-Gesundbrunnen branch railway operated in connection with the main line of the Prussian State Railways. This machine is of 300 h.p. capacity, the current being supplied by three overhead wires, double roller-contact underrunning trolleys being employed, while an auxiliary storage battery of sufficient capacity to operate the locomotive at full capacity for ¼ hour is provided in order to permit trains to be manipulated at the junction of the trolley and main roads.

Shifting engines for yard use are illustrated by an example of a small engine used at Gleiwitz. This is operated by an overhead trolley of the curved sliding bar type, with an additional radial movement so that it may readily pass from one line to another, and thus pass freely about the yards where it is used.

Some locomotives of the pure accumulator type are illustrated, although the scope of this form seems to be rather limited; among these may be mentioned those for use in the sugar refinery at Noerten, these having a weight of 17 tons, and a battery capacity enabling them to be operated for an entire day without recharging.

Herr Tischbein emphasises the advantages of electricity over steam for locomotive power, calling especial attention to the absence of reciprocating parts, and consequent freedom from vibration and hammer-blows upon the rails, and shows that the use of such machines as auxiliaries will gradually lead to their extended application. The case of the tunnel on the Baltimore & Ohio Railroad at Baltimore, in the United States, and of the announced intention of the use of electric traction on the prolongation of the Orleans Railway at Paris are cited to show the progress which has been made in this respect in other countries than Germany.

The Manufacture of Armour Plate.

In the construction of the modern battle-ship the question of amour plate has become one of the greatest importance, and no department of the metallurgy of steel demands more attention.

For these reasons, if for no other, the very complete paper of M. Baclé, in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* demands attention; forming as it does a treatise on the methods and products of the best European manufacturers. No attempt is made to discuss the subject from a military point of view, the side of the manufacturer rightly being considered the one of importance, another instance of the manner in which the engineer has taken a controlling position in matters military.

M. Baclé first calls attention to the contradictory qualities which are demanded in good armour plate. In the first place, it must be exceedingly tough, in order to be able to withstand the shocks and blows of projectiles without cracking or rupturing; at the same time it must possess a surface of extreme hardness, such as will cause the

projectiles to be shattered by the force of the impact; while with these essential properties the plate must be free as possible from internal stresses, even though the mass may weigh 25 to 30 tons and have been produced from an original ingot weighing more than 100 tons.

These requirements involve two things as necessities of an armour plate works; a plant fully equipped with powerful special machinery, and facilities for producing the proper material or alloy upon which to work.

The early armour was made of wrought iron, but since 1880 steel has come into use, either alone or in combination with iron for certain portions of the plating, and at the present time steel is practically entirely used, either with or without some hardening alloy, such as nickel. Examples of tests of some of the earlier wrought-iron plates are given in M. Baclé's paper, showing the manner in which the metal permitted projectiles to imbed themselves without causing cracks or extended fractures. Similar results were obtained with very soft steel plates shown at the Paris Exposition of 1889, but as this steel has little if any greater resistance than wrought iron it has not found acceptance except for special purposes. These soft steel plates were followed by the compound plates of Cammell and of Brown, in which a hard steel face was combined with a tough backing, the intention being to provide a hard enough surface to fracture the projectile, while the tough back portion prevented any cracks from extending through.

With the improvements in plates, however, came improvements in projectiles and increase in gun-power, and the substitution of the Holtzer for the Palliser projectile, together with the increase in striking velocity, demonstrated that something better than existing plates must be developed if effective armour protection was to be maintained. The result was the introduction of nickel-steel by the Creusot works, followed by the addition of the Harvey process of surface-hardening in America, and still later by the improved Krupp armour, this last representing the latest and most successful process.

Having thus reviewed the development of modern armour, M. Baclé proceeds to examine the results of tests made upon the proving grounds of different countries, giving illustrations of the results of many trials. In this connection he mentions the proposed method of Director Maupeou, of the French Navy, for comparing the relative resisting power of different plates. This method consists in selecting in all cases such a striking velocity for the projectile as will insure its piercing the plate. The velocities immediately before and after piercing the plate are measured, and the difference between them enables the amount of energy absorbed in the passage of the projectile through the plate to be very accurately determined. By using plates of such moderate thickness that they are readily pierced, the relative resistance of plates produced by various processes may thus be determined. Such piercing tests, made upon plates of moderate thickness, accompanied by impact tests upon heavier plates of the same makes, might enable more reliable conclusions to be reached than otherwise possible.

After reviewing chonologically the tests which have been made in various countries from 1880 down to 1898, including homogeneous metal, both soft and hard, compound armour, nickel steel, nickel-steel Harveyized, and Krupp armour, M. Baclé concludes with a summary showing the gradual and marked increase in resisting power which has been secured during the past twenty years. This advance is best appreciated when it is seen that with modern steel armour the resistance to the projectile is between three and four times that of a wrought-iron plate of the same thickness.

The whole paper forms a treatise on the development of modern armour-plate, and with its illustrations, and with the very carefully tabulated results of important trials all over the world, it is doubtless the most complete presentation of the subject which has yet been made.

REVIEW OF THE AMERICAN PRESS

The Canals of New York.

ONE of the most valuable engineering documents which has been made public for a long time is the report of the Committee on Canals of New York State to Governor Roosevelt, published officially in volumes, and given very fully in abstract both in *Engineering News* and in the *Engineering Record*. The impossibility of covering fully such a bulky document in the limited space here available is evident, but there are certain salient points which demand attention, and which stand out as of wider importance than as regards the canals of New York State alone.

The first of these is the possible competition of the canals and the railways. Upon this question depends the very future existence of the canal as an economical means of transport, and until this is settled it is useless to go further. If the railways can in the near future reduce the cost of transportation on such merchandise as grain, coal, lumber, etc., to a point lower than is possible on canals, then canal transport is doomed. The first duty of the commission then was to determine the minimum cost of such transport by the competing railways. This was done by a general inquiry into the present condition of railway freight-rates and by special inquiry of the presidents of three of the important railways handling similar traffic. The result was to the effect that there is no probability of a rate of 1 mill per ton-mile for low-grade freight, and that there is every prospect that rates will be higher and not lower than at present. The rates for water transport at present are as follows: on the ocean it averages half a mill per ton-mile; on the lakes, where the vessels are smaller and the waterway restricted at places, it is about 0.6 mill; and on the New York canals, with their present greatly restricted waterways and obsolete methods, the present cost is about 2 mills per ton-mile.

If the committee is right in its assumption, then, that with proper improvement the canal rate can be reduced to two-thirds of a mill per ton-mile, there is nothing to fear from the competition of the railways.

The second point of general importance in the report is the comparison between the advantages of a ship canal for sea-going vessels and a barge canal with reshipment at the seaport. The idea of a ship canal, reaching into the heart of the country, rendering it possible to deliver crude products for export to the rest of the world with but one loading, is most attractive, but apart from the constructive difficulties as regards such a waterway, the question ot the varying character of the navigation is to be considered.

In the opinion of the committee it is not practicable to build vessels adapted for navigation on the ocean, the canal, and the great lakes so that they can be operated with commercial economy. The ocean steamer costs about $71 per net ton of carrying capacity; the lake steamer can be built for $36 per ton; while a canal steamer and three barges of similar carrying capacity would cost but $7.31 per net ton. To combine these three types into one vessel, capable of performing the several duties with the same economy does not seem practicable, and to use the higher cost vessel for the lower cost service would cost more than to break bulk once at each end of the canal.

The next point is the emphasis laid upon the fact that the efficiency of canals depends quite as much upon their management as upon their physical size, and that for successful operation it is necessary that all restrictions upon the capitalization of canal-transportation be removed; that mechanical traction be introduced instead of animal power, including the mechanical operation of the locks and lifts; and that the force in charge of the works be placed on a permanent footing, affording an attractive career to graduates of technical schools, and providing a competent engineering staff for the conduct and care of the works.

An interesting feature of the report is

that portion which deals with the recent and future development of canals on the continent of Europe, a special investigation having been made for the information of the committee. In France the water traffic has increased 140 per cent. since 1870, while the railway traffic has only increased 75 per cent. In Belgium, Russia, and Germany, the extension of canals and the canalization of rivers has been very marked of recent years, showing that in countries where the keenest competition exists both internally and externally, an effort is made to gain an advantage or at least to keep on an equality in the competition by reducing the rates of transportation, and that to accomplish this large sums of public money are spent to improve the water routes. These facts confirm the general proposition that under equal conditions of management, the water route, even in a restricted way like a canal, is cheaper than the rail route.

The recommended project for the New York canals is mainly one of increase in capacity, by deepening, widening, lengthening locks, introducing mechanical lifts, and generally increasing the capacity to accommodate barges of 1,000 tons cargo with mechanical traction.

With this increase of capacity, and with the removal of all restrictions and the introduction of efficient operating management it is believed that the water transport of low-grade freight from the great lakes to the sea can be effected at a cost which will be decidedly lower than is possible by rail.

The Progress of the Mechanic Arts.

In the course of his address upon the occasion of the celebration of the seventy-fifth anniversary of the founding of the Franklin Institute, Dr. Coleman Sellers brought out some interesting points upon the development of the mechanic arts during the existence of the Institute, and from the *Journal of the Franklin Institute* some extracts are made.

After reviewing the early history of machine-tool making in the United States and showing the tendency in America to depart from inherited custom and practice whenever improvement could be made, Dr. Sellers goes on to speak of the present methods.

"The tendency to standardize everything is peculiar to the United States. Builders of locomotives in America adopt standard sizes and types of locomotives, and are thus able to manufacture such to great advantage. Railroads in America are willing to take from the builders what has been shown to be good and effective, and when the same kind of machine is to be duplicated many times, the maker can afford to invest heavily in special gauges and special tools that decrease the amount of manual skill required in laying out the work or in working to drawings. The first time a piece of work is done, whether it be small or large, simple or complex, more time is spent upon it than after the workmen have become familiar with its construction, and certainly more time than would be required after special appliances have been invented and made to cheapen the product, especially when the men are paid for their work according to the quality and quantity turned out, and not by a fixed wage per diem.

"It has been the scientific methods introduced by the managers of the railroads, aided by the skill and perfect equipment in their workshops, that have made those great railway systems what they are. They must exercise the utmost caution in all that they undertake; every alteration or deviation from adopted standards involves so many pieces that must be changed. In regard to the simple matter of making brake-shoes for the cars, and boxes for axle journals, I know from my own experience that it was not until the introduction of machines for moulding these pieces accurately, that the best results could be obtained and the parts made exact and perfectly interchangeable. Every invention, whether it be in the foundry or in the machine shop, is cumulative, and has its effect upon other trades, and through our ingenuity and progress we have now reached a point when the whole world looks to America for certain work which it seems cannot be done to equal advantage in other countries."

The question of technical education has had much to do with the development of the mechanic arts, and of its influence Dr. Sellers says:

"We are long past the period of empiri-

cal work. The steel-makers and iron-founders now depend upon metallurgists to guide them, while every well-equipped machine shop in the country must have its staff of educated men who are able to reinforce the practical knowledge of those engaged in manufacturing by exact mathematical methods that in the early stages of our profession were limited to simple arithmetic.

"Reviewing the century's progress, one cannot but be impressed with the tendency to specialize all industries. It has been truly said that jobbing shops are and always will be a necessity, but that manufacturing establishments will lead in the march of improvement. Trades are becoming more diversified, and time, talent, and capital are being expended upon individual machines and appliances as special which were formerly but a part of the output of single establishments. To this concentration of the best thought upon special branches of all industries we may attribute much of the progress in the mechanic arts made during the past seventy-five years, which has opened the markets of the world to the products of our industry."

Mechanical Stokers.

THE desirability of substituting mechanical stoking for hand labor is a matter about which there is little difference of opinion, the principal questions arising being those of cost, expediency, and adaptability. The subject is so often complicated with matters not directly belonging to it that the paper of Mr. W. E. Snyder, recently read before the Engineers' Society of Western Pennsylvania, and published in the *Proceedings* of the society, is altogether welcome, treating as it does of the furnace considered apart from the boiler, as a device for the efficient combustion of fuel.

Ordinarily the performance of a furnace is complicated with that of the boiler with which it is operated, the efficiency being considered as measured by the evaporation, regardless of the fact that the evaporation is largely affected by the character of the boiler and of its setting. Mr. Snyder, on the contrary, seeks to find an expression for the efficiency of the furnace itself as a means of comparing various methods of conducting combustion, realizing that it is absurd to measure the efficiency of a device for generating heat by the ability of an entirely independent apparatus to absorb that heat.

In endeavoring to establish an independent standard of furnace-efficiency Mr. Snyder assumes that the perfect furnace delivers only gaseous products of complete combustion to the chimney, and only incombustible earthy matter to the ash-pit, and uses no more air than is sufficient to supply the oxygen to unite with the oxidizable components of the fuel. By measuring the losses which occur by passage of unburned fuel to the ash-pit, unburned gases to the chimney, and excess air admitted and carrying away heat, we are able to determine the extent to which a furnace departs from this perfect performance, and so obtain an efficiency for it entirely apart from that of the boiler to which it may be attached. Mr. Snyder gives several examples of this method of determining the efficiency of furnaces and shows how it enables the engineer to study the real value of a given furnace. If the furnace loss is low, indicating good combustion, but a low evaporation is shown by good coal, no blame should be placed on the furnace. The heat generation has been proven efficient; the responsibilty for its efficient absorption lies with the boiler.

Comparing different methods of firing, according to the above idea of furnace-efficiency, the defects of the common grate are very apparent. It permits some coal to fall through into the ash-pit, and it requires a large excess of air to enter when firing, while at the same time the chilling of the furnace prevents complete combustion, so that the losses at all the points are necessarily large. Instead of providing the essentials to good furnace economy, *i. e.*, high furnace temperature and proper air supply, there is a fluctuating furnace temperature and large volume of excess of air at times. The defects of the ordinary grate are not diminished by the use of the various shaking or other grates of special design, these only serving to assist the fireman in the work of cleaning, and in no way removing the great defect of intermittent firing through open doors.

Various principles of design have been adopted in the attempts to make a mechani-

cal stoker which shall obviate the defects of hand firing, and apart from the saving of manual labor the object which they all have in view is the uniform and continuous supply of the fuel, together with a properly regulated supply of air, so that as perfect a combustion as possible may be secured.

The mechanical devices used in stokers may be of three kinds: One acts to spread the fuel upon the fire, another feeds it at one end, and the third feeds it up from beneath. In each of these the gaseous products are supposed to be fully consumed, either by passing over the incandescent fuel, or by passing through the bed of burning coal.

The first class is represented by several makes used in England and on the Continent, but is little used in America, where the second type, with inclined grates, is more common. In both of these good combustion can be secured, and a number of successful installations have been made, but there are certain defects which act to prevent the highest attainment of efficiency. Although the combustible gases produced by the coking of the coal are passed over the incandescent bed, which is at a temperature probably as high as 2,500° F., yet they are also obliged to pass under and near the surface of the boiler, which is not hotter than 400° F. The result is that only a partial combustion is attained, and some unburned gases go out at the chimney. The action of the open and moving grate-bars of such stokers is also defective in that much fuel falls through unburned into the ash-pit. Nevertheless such stokers are doing good work in many places, and when their efficiency is considered apart from that of the boilers under which they are placed their superiority to the ordinary grate is evident.

When the fire is fed from beneath, as in the third class above mentioned, these difficulties are modified. The combustible gases arising from the distilled coal have to pass through the fuel bed; and, if the proper quantity of air is present, they will be fairly well burned, although there must doubtless be a portion of the chilling effect of the boiler surface yet present. The solid cast floor prevents the loss of fuel, and this feature renders this type well adapted for burning inferior and finely divided fuels, so that the choice of a stoker should in a measure be governed by the character of the fuel with which it is to be used. The nature of this type of stoker renders forced draft necessary, and this feature enables the rate of combustion to be controlled by regulating the draft, while the high rate of combustion thus attained gives also a high temperature and permits a decrease in the amount of air per pound of coal.

It is evident that the laws of combustion must be observed in the design of a stoker if good results are to be obtained. The extent to which these laws have been observed can be determined by the character of the solid and gaseous products of the furnace, and when the efficiency of the furnace is determined from these data results are obtained which are comparable with those obtained in a similar manner from other furnaces. There is no doubt that in all cases, mechanical stoking, properly conducted, is better than hand firing, but it must not be expected that careless usage and neglect will conduce to good results. A higher grade of attendance is given to a first-class Corliss engine than to a common plain slide-valve engine, and what is good sense in the engine room is also good sense in the boiler room.

The Cost of High Speed Trains.

THERE has been much discussion of late about the high speeds which have been attained by express trains, both in the United States and in Europe, but the question of the cost of these high speeds is a matter about which little is definitely known. For this reason the paper of Mr. F. A. Delano, recently presented before the Western Railway Club, is of especial value, and although it relates altogether to American practice it will be found applicable in other countries as well.

The additional cost of fuel is but one of the items of increased cost, but even this item is somewhat uncertain. According to the formula of the Baldwin Locomotive Works, the increased resistance caused by running at a speed of 60 miles per hour as compared with 30 miles, would cause an increase of 62½ per cent. in fuel consumption, but practical experience shows that the ac-

tual increase is more nearly 100 per cent. This is doubtless due to the diminished economy of the engine at the higher speeds, as is shown by the indicator cards, but even if the fuel consumption is doubled the distance is covered in one-half the time, so the actual fuel cost of traversing a given distance is not altered.

The largest factors in the cost are the indirect items. "No expense is spared to prevent breakdowns or failures of any kind. Even the waste which is put in the oil boxes of cars and engines is of a special quality; the journals are burnished; the brasses are specially scraped or machined; the coal which is put on the tanks is selected coal, broken in advance so that the fireman will not be obliged to break it. The locomotive itself is looked over by the best mechanics, and the master mechanic gives a large share of his thought and atention to the condition of the engines and cars in such trains. In the superintendent's and despatcher's office special attention is given to avoid delays; in the maintenance of way department, from the roadmaster to the section man, the constant thought is to make the track safe for this special service. In other words, the entire character of the service is keyed up to a necessarily high pitch, which, while accruing in a measure to the benefit of the other service, nevertheless adds expense which it is impossible for any man to more than guess at."

A serious element in the cost of running high-speed trains is the delay which is caused to other traffic. A slow train preceding a fast one must soon be overtaken and compelled to take a side track, while a slow train following is soon distanced, and hence the fast train soon has gaps in front and behind it, throwing a large portion of track out of effective use for other purposes. Since the maximum amount of business is done by having the speed of all trains as nearly uniform as possible, it will be seen that a single fast train upsets all idea of conducting the balance of the traffic on the most economical plan, and the increased cost is properly chargeable to the fast train.

These facts have not always been considered in computing the cost of running fast trains, and while the earnings of such trains may be much larger than those of the slower trains it is questionable whether they are justified in view of the increased cost.

Apart from the immediate cost of fast trains, their introduction has acted to increase the cost of transportation in general.

It has led to the construction of larger and more powerful engines, and has educated the public as well as railway men to the point where the old-fashioned speed of 20 to 30 miles an hour is considered slow, even for freight. While this need not necessarily be considered a disadvantage, yet at the same time it is a matter which has very materially increased the general cost of railway service.

Mr. Delano, while maintaining that high speed costs heavily, was not prepared to give any definite figures on his own account, but stated that the superintendent of an important trunk line recently gave the cost of operating an extra fast train as $2.00 per train mile. Since the method by which this figure was reached was not explained it may be nothing more than a guess, but it appears to be none too high in the opinion of experienced railroad men.

It is not only the steam railways which have educated the public to a demand for high speeds. Cable traction surpassed the old horse cars only to be exceeded themselves by the electric cars, and local and suburban traffic is now as rapid as former through express trains. What the limit will be, or whether there has been a real benefit by this increase in transportation, remains to be seen. So far as trunk-line traffic is concerned it has hardly paid its cost, but in suburban transportation the increased value which local rapid transit has given to suburban property has doubtless proved a far greater indirect benefit than the cost of the service.

Another feature which appears to be altogether overlooked in Mr. Delano's paper is the value of fast trains as an advertising feature of the roads by which they are operated. From the manner in which publicity is given to the performance of the extra fast trains it is very evident that the railways find them of value in calling attention to their service, and that the general business of the road is "boomed," so to speak, by the fact that it possesses some well-advertised flyer. This may not be exactly en-

gineering, but it is business, and among the large sums expended for advertising an allowance should be made for the advertising value of the fast trains. In this respect the railroads are much like the transatlantic steamship lines, and the possession of a record-holder may sometimes cost more than it is worth so far as the especial vessel or train is concerned, and at the same time be a very valuable advertising medium to draw business to the line as a whole.

Failures in Asphalt Pavements.

ASPHALT pavements have come into such very general use, and have so many advantages that it is desirable that their weak point be fully ascertained in order that if possible improvements may be made and failures avoided wherever possible. For this reason the report of Captain Lansing H. Beach, Engineer Commissioner of the District of Columbia, is of especial value to municipal engineers for the article it contains by Mr. A. W. Dow upon the causes of failures in asphalt pavements.

The failures of asphalt pavements may be broadly divided into three classes: disintegration by cracking, disintegration by rolling or waving, and disintegration in spots.

The formation of long irregular cracks is due to contraction of the asphalt surface by cold. It is rare to find the crack in the concrete foundation, and the fact that such cracks often have their origin at iron manholes and the like shows that unequal contraction is the cause. Such cracks also occur sometimes at a joint made between a new pavement and an old one, or between one day's work and another, although the latter should not be the case if the work has been properly done. It is found that cracks appear sooner and increase more rapidly on streets with little or no traffic, the action of the traffic appearing to knead the surface together and prevent the formation of cracks. The proportioning of materials to prevent cracking depends somewhat upon the climate and the exposure of the street, a north and south street exposed to a wide range of temperature being the most difficult. The best asphalt surface to meet these conditions should be made with a sharp sand, well graded from coarse to fine, with the fine predominating and with as much asphalt cement as the sand will hold. The asphalt cement should be as soft as is practicable without having it mark too badly in the hottest weather.

Disintegration from rolling or crowding occurs when the wearing surface is too soft, or where the bond between base and binder, or between the binder and bearing surface, is defective. The traffic then pushes the surface of the pavement up into waves or crowds it toward the gutters. It is naturally greatest in streets subjected to heavy traffic, and in some such cases it cannot be entirely prevented, but it should not occur in streets carrying even a moderately heavy traffic, and should it appear it may be considered due to one or both the above causes. The concrete base should not be made too smooth, and if the binder and surface mixtures are too soft they will slide on the base. The crowding is generally supposed to be due to a soft surface, while in fact it is much more generally caused by a defective base or binder, and when proper care is taken to secure a perfect union between the parts, disintegration from this cause should not occur.

Disintegration in spots may be due to a number of causes. In a defective pavement there will always be some portions weaker than others, and in addition to this the irregular distribution of wear will naturally appear. When the surface mixture is deficient in asphalt-cement brittle spots will form in cold weather and these will be ground away by the traffic. Sometimes oil coming from the binder is absorbed by the surface mixture, rendering it soft and making it susceptible to the action of water, and such spots are rapidly worn away.

Another serious cause of deterioration is that due to the absorption of illuminating gas escaping from leaky gas pipes or mains under the pavement, this appearing to be a common occurrence in all cities having gas. The effect begins by the appearance of fine cracks, after which the pavement begins to crowd, and pieces of the surface mixture taken up smell very strongly of illuminating gas.

The asphalt is sometimes so heavily charged with illuminating gas that it can be ignited by application of a match, and in nearly every case enough gas will be given off by heating a small piece of the affected

pavement in a tube, to have it flash by igniting.

There has been some doubt as to this disintegrating action of illuminating gas upon asphalt, but Mr. Dow cites in detail his experiments, which demonstrate conclusively that the asphalt absorbs the hydrocarbon gases and a little methane, the asphalt becoming much softened. The only way to stop this form of deterioration is to stop the leaks; repairing is useless, as the trouble soon reappears, and it is the source which must be removed.

An asphalt pavement may become disintegrated by water oozing up from beneath, the action being a rotting of the under portion of the surface mixture, after which the upper portion becomes crowded out by the traffic. As with gas, the remedy for this trouble is the removal of the source.

It will be seen that there are many other causes for the deterioration of asphalt pavements besides defective material, and that all, or nearly all, of these causes are preventable. Indeed it is not too much to say that better results can be obtained with poor materials carefully used, than with the best materials which have not proper care given to them. When the best materials are used, however, and the best care given as well, there is no good reason why asphalt pavements need give trouble, and a careful examination into the disintegrating of a pavement may, in many, if not most cases, be found due to causes entirely foreign to the composition of the material, causes which could be easily remedied with the exercise of a little common sense.

The Economy of Mechanical Draft.

THE advantages of forced draft in steam generation have generally been supposed to rest in the better control which is given over the combustion, and the ability to meet sudden demands for steam promptly.

In a paper recently presented before the Boston Society of Civil Engineers, by Mr. Walter B. Snow, and published in the *Journal of the Association of Engineering Societies,* the question of the influence of mechanical draft upon the ultimate efficiency of steam boilers was discussed, and some points of interest upon that side of the subject were brought out.

After describing the various methods of producing mechanical draft by the plenum and vacuum systems, with details of various installations, Mr. Snow proceeded to discuss the several elements of efficiency. Taking a case of a plant of 2,400 horse-power of modern water-tube boilers, equipped with economizers and set with chimney draft and also with mechanical draft, all other things being assumed equal, it appears that there is a saving in first cost of $6,400 on a total cost of $79,100, by the use of the mechanical draft instead of the chimney. Again the employment of mechanical draft will permit the use of deeper fires and a higher rate of combustion, so that the full actual capacity will be obtained with boilers of but 2,000 horse-power capacity under the lighter draft, and with equal economy, so that a further saving of one-sixth of the first cost of boilers may be made.

Turning now to operative costs, it appears that with mechanical draft properly applied, a large portion of the heat which escapes up the chimney with natural draft may be saved. The actual power required to operate the fan is only about one-seventy-fifth that required to produce the same draft in a chimney by the ascending force of a column of heated air. The remainder of the heat may therefore be saved by the use of suitable heat abstracting devices, and this is the real source of the economy of mechanical draft.

In other words, by the use of the economizer for heating the feed-water, and of the air heater for heating the air supplied to the furnace, the waste of the flue gases may be reduced to only 5 per cent. of the total heat value of the fuel. The economy due to better combustion caused by the higher furnace temperature is also a feature of the use of mechanical draft as well as the closer regulation of the air supply to the actual demands of the combustion. When to this is added the ability to burn low-grade fuels at good rates of combustion it will be seen that the opportunities for economy are great.

It is evident from the points which have thus been made, that the advantages of mechanical draft are not so much those which are inherent in the system as those which may be added to it or introduced because of it. Theoretically the furnace has no way of knowing how the air which

it receives is brought to it. Practically it is possible so to bring the air that it may be better applied, and better controlled, and that less heat need be wasted, and more heat may be applied to useful work. These things the mechanical draft cannot do of itself, but it can render it possible for them to be done. Like many other good things, it requires to be set to work with judgment and kept at work with intelligence, and under such conditions it will do good work.

The Automobile Movement.

In discussing the different phases of the automobile movement in different countries Mr. M. C. Krarup, in the *American Machinist*, endeavors to discover why the United States has not taken the same advanced position in that line of industry as it has in other departments of applied mechanics.

It must be remembered that the department of automobilism which has advanced to the highest position on the Continent is that of light pleasure vehicles, suitable for the pastime of a leisure class in countries where the roads and streets are of the best. Under such conditions the development of the petroleum and gasoline motor, and their application to the pleasure motor-vehicles rapidly attained a high degree of popularity, although it has failed to meet with the same enthusiastic reception in America.

That this state of affairs is likely to work injury to the cause of automobile traction in the United States need not be feared, on the contrary it will probably only serve to cause its greater progress along other lines. At the present time the requirements for an automobile vehicle are that it should be capable of supplanting animal power for transportation purposes on common roads. How this can best be done is a problem for the engineer and the mechanic to solve, and with the advantages of American automatic machinery and the widely diffused knowledge of its proper use, and with the full knowledge of the difficulties to be overcome in practical operation, there is every reason to believe that American designed vehicles, not imitations of foreign machines intended for an entirely different service, will prove entirely adequate to meet the conditions.

It is suggested that the line along which development can best be undertaken is that of the separate tractor, for attachment to vehicles of the ordinary sort, and there is no doubt that this idea lends itself especially to the plan of systematized construction so necessary for commercial success. Thus the automobile of to-morrow may be a combination of a motor or tractor, and a vehicle, while the automobile of to-day is a full-fledged self-propelled vehicle, a sort of infant prodigy, overgrown, and without the necessary stamina to endure the tests of life and the give-and-take of commercialism.

THE ENGINEERING INDEX

INTRODUCTORY.

The object of this Index is to supply all persons interested in engineering and industrial pursuits with, first, an expert descriptive summary clearly indicating the character and purpose of the leading articles published currently in the established technical journals of the United States, Great Britain, and the Continent—in all languages; and, secondly, an inexpensive means of readily obtaining any portions of this literature that may be desired by our readers.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *qr*, a quarterly, *s-q* semi-quarterly, etc. Other abbreviations used in the Index are: Ill—Illustrated; W—Words; Anon—Anonymous.

American Architect. *w.* Boston, U. S. A.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Geologist. *m.* Minneapolis, U. S. A.
American Jl. of Science. *m.* New Haven, U. S. A.
American Machinist. *w.* New York.
Am. Manufacturer and Iron World. *w.* Pittsburg, U. S. A.
American Shipbuilder. *w.* New York.
Annales des Pontes et Chaussées. *m.* Paris.
Architect. *w.* London.
Architectural Record. *q.* New York.
Architectural Review. *s-q.* Boston, U. S. A.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Automobile Magazine. *m.* New York.
Automotor & Horseless Vehicle Jl. *m.* London
Bridges. *m.* Chicago.
Brick Builder. *m.* Boston, U. S. A.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin Am. Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bull. Int. Railway Congress. *m.* Brussels.
California Architect. *m.* San Francisco, U. S. A.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.

Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Contemporary Review. *m.* London.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Eclairage Electrique. *w.* Paris.
Electrical Engineer. *w.* London.
Electrical Engineering. *m.* Chicago.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Cleveland, U. S. A.
Engineers' Gazette. *m.* London.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penn'a. *m.* Pittsburg, U. S. A.
Fire and Water. *w.* New York.
Foundry. *m.* Detroit.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e d. Str. Ferr. *w.* Rome.
Glaser's Ann. f. Gewerbe & Bauwesen. *s-m.* Berlin.
Heating and Ventilating. *m.* New York.
Horseless Age. *m.* New York.
Ice and Refrigeration. *m.* New York.
India Rubber World. *m.* New York.
Indian and Eastern Engineer. *m.* Calcutta.
Industries and Iron. *w.* London.
Inland Architect. *m.* Chicago.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron & Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland.
Journal Assn. Eng. Socities. *m.* Philadelphia, U. S. A.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery. *b-m.* Fort Monroe, U. S. A.
Journal Western Soc. of Eng. *b-m.* Chicago, U. S. A.
L'Energie Electrique. *w.* Paris.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* London.
Machinery. *m.* New York.
Marine Engineer. *m.* London.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Master Steam Fitter. *m.* Chicago.
Mechanical World. *w.* London.
Mechanical Engineer. *w.* Manchester.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco, U. S. A.
Mining Journal. *w.* London.
Mining Reporter. *w.* Denver, U. S. A.
Mitt. aus d Kgl. Tech. Versuchsanst. Berlin.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Moniteur des Architects. *m.* Paris.
Moniteur Industriel. *w.* Paris.
Municipal Engineering. *m.* Indianapolis, U. S. A.
National Builder. *m.* Chicago.
Nature. *w.* London.
Nature. *w.* Paris.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
Oest. Monatsschr. f. d. Oeff. Baudienst. *m.* Vienna.
Oest. Zeitschr. f. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Proceedings Engineers' Club. *qr.* Philadelphia U. S. A.
Progressive Age. *s-m.* New York.
Railroad Car Journal. *m.* New York.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway Magazine. *m.* New York.
Railway Master Mechanic. *m.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Review of Reviews. *m.* London & New York.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Marittima. *m.* Rome.
Sanitary Plumber. *s-m.* New York.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Indicator. *qr.* Hoboken, U. S. A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. of Civil Eng. *m.* New York.
Trans. Am. Soc. of Heat & Ven. Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Transport. *w.* London.
Western Electrician. *w.* Chicago.
Wiener Bauindustrie Zeitung. *w.* Vienna.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *s-m.* Halle a. S.
Zeitschrift für Elektrotechnik. *s-m.* Halle a. S.

ARCHITECTURAL ENGINEERING

CONSTRUCTION.

Apartment Houses.

The Design of a Modern Apartment House. Illustrated description of the various portions of a mechanical plant which must be taken into consideration in planning such a structure, as exemplified in a New York apartment house. 3000 w. Eng Rec—Jan. 20, 1900. No. 31995.

Church.

The Mormon Tabernacle, Salt Lake City, Utah. W. P. Hardesty. Illustrated description of this unique structure, its large timber arches, methods of erection, and its heating and cooling system. 2200 w. Eng Rec—Jan. 27, 1900. No. 32089.

Domes.

The Dome as the Basis of an Architectural System. Arthur Bolton. Read at a meeting of the Archt. Assn., London. An interesting paper, giving a critical survey of past methods, many illustrations and suggestions, and also editorial. 13500 w. Builder—Jan. 20, 1900. No. 32224 A.

Exposition.

The Machinery Hall and the Building for Chemical Industries (Palais de la Mécanique et Palais des Industries Chimiques). René Weil. Devoted especially to a description of the structural framework and the methods of erection of these important buildings of the Paris Exposition. Two articles. 2 plates. 4500 w. Génie Civil—Dec. 30, 1899, Jan. 6, 1900. No. 32105 each D.

The Monumental Entrance at the Place de la Concorde (Entrée Monumentale de la Place de la Concorde). Alfred Boudon. A description of the main entrance to the Paris Exposition, with a plate showing details of construction, and numerous views, giving the present condition of the work. 2000 w. 1 plate. Génie Civil—Dec. 16, 1899. No. 32100 D.

Mausoleum.

The Somerton Hills Mausoleum. Illustrated description of a receiving vault having an unusual arrangement of double walls and roofs to obtain good circulation of the air. 1100 w. Eng Rec—Dec. 30, 1899. No. 31674.

Public Building.

The New Home of the New York Supreme Court of Appeals. Illustrated description of an elaborate building in New York, particularly planned to expedite judicial procedure. 1500 w. Eng Rec—Jan. 6, 1900. No. 31771.

Structural Ironwork.

Details of Structural Iron and Steel. Information with regard to this work that may be applied in practice. Part first begins the study of materials. Ill. 2500 w. Builder—Jan. 6, 1900. Serial, 1st part. No. 31942 A.

Trussed Roof.

Reconstructing a Trussed Roof. Illustrated description of the methods adopted in remodeling a heavy roof of a St. Louis synagogue. 1000 w. Eng Rec—Jan. 6, 1900. No. 31768.

Underpinning.

Underpinning Shop Walls. Illustrated description of the different methods employed in supporting the walls of a shop engaged in heavy manufacturing while a tunnel was being driven in sandy soil near by. 1200 w. Eng Rec—Jan. 13, 1900. No. 31887.

Warehouse.

The Export Sugar Warehouse at the Port of Dunkirk (L'Entrepôt Reél des Sucres Indigènes du Port de Dunkerque). A. Boudon. A detailed account of this important structure, with especial reference to the construction of the foundations in loose sand. 2000 w. 1 plate. Génie Civil—Dec. 23, 1899. No. 32102 D.

HEATING AND VENTILATION.

Air Ducts.

Dangerous Air Ducts. Abstract of a paper by John Gormly, read at meeting of Heat. and Ven. Engs., describing construction liable to distribute sewer air through a building. 600 w. Eng Rec—Jan. 27, 1900. No. 32090.

Blower System.

Condensation of Steam in Blower Systems of Heating. Reviews experiments by R. C. Carpenter with a 48-in. blower, heater coils and engine. 2500 w. Eng Rec—Jan. 27, 1900. No. 32091.

Boiler Rating.

The Rating of Boilers for Heating Purposes. Describes experiments by John Mackay and gives two tables from which the sizes of boilers can be determined having given the amount of radiation to be supplied and the rate of coal consumption. 1400 w. Eng Rec—Jan. 27, 1900. No. 32092.

Boiler Shop.

Heating a Locomotive Boiler Shop. Tells of the successful application of a heating system and gives diagram showing effect of velocity in increasing relative condensation in heater. 600 w. Loc Engng—Feb., 1900. No. 32240 C.

We supply copies of these articles. See introductory.

Boilers.

House-Heating Boiler Capacities. Opinions of experts as to desirable commercial ratio between steam and hot-water boilers. 9000 w. Heat & Ven—Dec., 1899. No. 31696.

Forced Ventilation.

Mechanical Ventilation and Heating by a Forced Circulation of Warm Air. Walter B. Snow. Lecture delivered before the Engs' Club of Yale University. A description of this system, with information concerning methods, costs, etc. Ill. 3500 w. Yale Sci M—Jan., 1900. No. 31858 C.

Heating Water.

The Computation of Hot Water Generators (Berechnung der Warmwassererzeuger). E. Brauss. Devoted to apparatus for producing warm water for bath and household use, whether heated by steam coils or by direct firing. 1800 w. Gesundheits-Ingenieur—Dec. 15, 1899. No. 32152 B.

Hot Water.

Central Station Heating in Connection with Electric Lighting Plants. W. H. Schott. Read before the Northwestern Elec. Assn. Advocates the installation of a hot-water system. 700 w. Elec Rev, N. Y.—Jan. 24, 1900. No. 32086.

Pottery.

Ventilation and Heating of the Rookwood Pottery, Cincinnati. Illustrated description of the mechanical plant which is relied on for the entire heating of a pottery devoted exclusively to the highest branches of ceramics. 1300 w. Eng Rec —Jan. 13, 1900. No. 31888.

School-House.

Ventilation and Heating of a Baltimore School-House. Illustrated account of the system of mechanical draft heating, which can be adopted where the climate is temperate. 1200 w. Eng Rec—Jan. 6, 1900. No. 31770.

Hot-Air Furnaces for Small School-Houses. A statement of the opinions held in Boston, New York, Chicago, and Philadelphia, all being in favor of hot-water or steam heating. 1000 w. Eng Rec—Jan. 20, 1900. No. 31994.

Stoves.

The Care of Stoves for Household Warming (Beobachtung und Wartung Unserer Zimmeröfen). Erwin Nicholaus. Discussing the dangers attending the use of the porcelain stoves so common on the Continent, especially with regard to the production of suffocating gases. 5000 w. Gesundheits-Ingenieur—Dec. 31, 1899. No. 32153 B.

Ventilation.

The Value of Ventilation (Der Wert der Ventilation). H. C. Nusbaum. A review of a recent work by Dr. Krieger, discussing at length the importance of proper ventilation of public school houses, as well as suitable means for accomplishing the result. 4000 w. Gesundheits-Ingenieur—Dec. 15, 1899. No. 32151 B.

Ventilation Without Draughts. Arthur Rigg. Discusses various systems, and gives the author's views of essentials to efficient ventilation. General discussion. Ill. 10000 w. Jour Soc of Arts—Jan. 19, 1900. No. 32206 A.

PLUMBING AND GAS FITTING.

Frozen Pipes.

Frozen Boiler Connections. Describes the thawing of the connections to a kitchen boiler, and water back. 1200 w. Met Work—Jan. 13, 1900. No. 31878.

Manila.

Sanitation in Manila. C. W. Iredale. Illustrated description of the conditions and the plumbing work found there. 2000 w. Dom Eng—Jan., 1900. No. 32002 C.

Nipples.

Nipple-Cutting and Threading. Orion Tutt. Illustrates and describes the work. 3000 w. San Plumb—Jan. 1, 1900. No. 31838.

Office Building.

Plumbing in the Dun Building, New York. Illustrates and describes the work in a 15-story office building in which the required pressure on the pipes is afforded by compressed air cylinders in the basement, rather than tanks on the roof. 1400 w. Eng Rec—Jan. 20, 1900. No. 31996.

Public Baths.

The Public Baths of Bilston, Staffordshire, England. James H. Fuertes. Illustrated description of the arrangements of an establishment designed to accommodate 4,000 people per week. 700 w. Eng Rec—Jan. 20, 1900. No. 31993.

MISCELLANY.

Fire Prevention.

Fire Prevention in 1899. Editorial on the paper of Thomas Blashill, and the lessons learned from tests and experience. 4200 w. Engng—Dec. 22, 1899. No. 31-724 A.

The Architect in Relation to Fire Prevention. Thomas Blashill. Abstract of paper read at meeting of the Roy. Inst. of Brit. Archts., with discussion. Considers progress and methods. 8500 w. Builder —Dec. 23, 1899. No. 31711 A.

Fireproofing.

An Unscientific Inquiry Into Fireproof Building. Russell Sturgis. A discussion of what may be done to make buildings more truly fireproof, what restrictions should be maintained, etc. Ill. 10000 w. Arch Rec—Jan., 1900. No. 32245 C.

CIVIL ENGINEERING

BRIDGES.

Atbara.

The Atbara River Bridge. Richard Khuen, Jr. A brief account of the events that led to the construction, and of the negotiations, with illustrated description of the engineering features. 5500 w. Pro Engs' Club of Phila—Dec., 1899. No. 31-777 D.

Drawbridge.

An Elevated Railway Drawbridge in Boston. An illustrated description of a new street bridge, built at a cost of about $1,500.000. 1000 w. St Ry Jour—Jan. 6, 1900. No. 31802 D.

France.

Some Recent French Bridges (Einige Neuere Französische Brückenbauten). Herr von Frahm. A general review of recent structures, describing the Mirabeau and the Alexander bridges in Paris. the Viaur viaduct, and various railway bridges. Two articles. 6000 w. Stahl und Eisen—Dec. 1, 15, 1899. No. 32143 each D.

Long-Spans.

Long-Span Bridges. William H. Burr. An illustrated discussion of the design of such bridges. Also brief general discussion. 6500 w. Pro of Engs' Club of Phila —Dec., 1899. No. 31776 D.

Paris.

New Railway Bridges in Paris. Illustrated description. 1800 w. Engr, Lond —Jan. 5, 1900. No. 31917 A.

Railway Bridge.

The Davenport and Rock Island Bridge Over the Mississippi River. Illustrates and describes the general details of the latest bridge to be constructed across the Mississippi River, giving also its history. 3800 w. Eng News—Jan 11, 1900. No. 31866.

Short-Spans.

Short-Span Railroad Bridges. Illustrated description of some structures designed for unusually high loads and very low unit stresses; includes a description of special templates for reaming. 1200 w. Eng Rec—Dec. 30, 1899. No. 31667.

Suspension.

An Old Chain Suspension Bridge. Malverd A. Howe. Data relating to the old chain bridge crossing the Merrimac River near Newburyport, Mass. Ill. 700 w. R R Gaz—Jan. 5, 1900. No. 31760.

Tugela River.

The New Colenso and Frere Bridges. Illustrated descriptions of bridges over the Tugela River in South Africa, being made in England to replace those destroyed by the Boers. Also account of the rapid work. 800 w. Engr, Lond—Jan. 19, 1900. No. 32212 A.

Vibrations.

A Study of the Vibrations of Bridges (Etude des Mouvements Vibratoires dans les Ponts). E. Lebert. A mathematical analysis of the vibratory actions in single-span girder bridges and in suspension bridges in which the floor simply rests upon the piers. 15000 w. Ann des Ponts et Chaussées—3 Trimestre, 1899. No. 32-122 E + F.

Victoria Bridge.

The Victoria Bridge Over the Dee at Queensferry. Thomas Walter Barber. Read before the Inst. of Civ. Engs., England. Describes a telescopic or rolling girder bridge. 2000 w. Ir & St Trds Jour—Dec. 30, 1899. No. 31870 A.

Y-Bridge.

The Zanesville, O., Timber Howe Truss Y-Bridge, Built in 1831-2. Illustrates and describes an interesting wooden bridge crossing the Muskingum and Licking rivers at their junction. 1000 w. Eng News—Jan. 25, 1900. No. 32069.

CONSTRUCTION.

Barcelona.

Provincial Public Works, Barcelona (Obras Publicas Provinciales, Barcelona). Victoriano Felip. An argument for greater activity in the planning and construction of highways, water-works, and other public works demanding attention. 6000 w. Revista de Obras Publicas—Jan. 4, 1900. No. 32188 D.

Croton Dam.

The Foundations of the New Croton Dam. Charles S. Gowen. Deals with all the features of the work pertaining to the foundations, giving illustrations, sections and plates, and account of work. 18500 w. Pro Am Soc of Civ Engs—Jan., 1900. No. 32050 E.

Docks.

Floating Dry Docks in America. Waldon Fawcett. A brief account of the docks already acquired and in process of construction. 1200 w. Mod Mach—Jan., 1900. No. 31660.

The Construction of the Third Graving Dock at Missiessy (Travaux de Construction du 3me Bassin de Radoub de Missiessy). M. Guiffart. An account of the new graving dock at the port of Tou-

lon. A caisson of structural and sheet iron was first constructed and filled with masonry. 10000 w. 3 plates. Ann des Ponts et Chaussées—3 Trimestre, 1899. No. 32120 E + F.

The Lesson of Timber Dry Docks. A statement of the relative prime cost of timber and masonry docks and of their maintenance, from the records of the U. S. Navy Department. Indicates that masonry docks are much cheaper in the end. 1400 w. Eng Rec—Jan. 13, 1900. No. 31879.

The Reconstruction of a Dry Dock. Illustrated description of the methods employed in building an old timber dock in the Brooklyn navy yard into a concrete dock. 1400 w. Eng Rec—Jan. 20, 1900. No. 31989.

Drainage.

Erection of a Drainage Plant. An illustrated account of the erection of a plant at Port Mourant, Berbice, British Guiana. 1700 w. Engr, Lond—Jan. 5, 1900. No. 31916 A.

Dredging.

The Measurement of Dredged Materials. A description of the investigations at Buenos Ayres to determine the relation between place and scow measurements. 1500 w. Eng Rec—Jan. 6, 1900. No. 31773.

Excavation.

A Belt Conveyor for Foundation Work. Illustrated description of the method of excavating the site of a large power house by means of wheel-scrapers emptied through chutes on a belt conveyor placed in a trench and discharging outside the lot limits. 900 w. Eng Rec—Jan. 13, 1900. No. 31881.

Lighthouse.

The Construction of the Eckmuhl Lighthouse (Construction de l'Edifice du Phare d'Eckmuhl). M. Duperrier. Devoted especially to the construction of the tower and buildings, and to the general and ornamental features. 5000 w. 1 plate. Ann des Pont et Chaussées—3 Trimestre 1899. No. 32121 E + F.

Masonry Joints.

Masonry Construction with Cast Metallic Joints (Maçonneries avec Joints Métalliques Coulés). H. Tavernier. A study of the construction of poured metallic joints for use with masonry arches for the control of the line of pressure. Experiments with the trial arch at Saint Chamond are discussed. 16000 w. 1 plate. Ann des Ponts et Chaussées—3 Trimestre 1899. No. 32119 E + F.

Roads.

Country Roads (Caminos Vecinales). Discussing a proposition that the people of Segovia, Spain, be allowed to build needed roads without securing government consent, which, it is claimed, is withheld. 3000 w. Revista de Obras Publicas—Dec. 14, 1899. No. 32185 D.

Shore Improvements.

Shore Improvements at Blackpool. Illustrated description of the construction of a new promenade, sea wall, etc. 1000 w. Engng—Jan. 19, 1900. No. 32213 A.

Stresses.

How to Determine the Stresses in Scissors Trusses. F. E. Kidder. An explanation of the peculiarities in the application of the method for determining stresses in this type, which is much used in roofing. Ill. 2000 w. Archts' & Builds' Mag—Jan., 1900. Serial, 1st part. No. 31740.

Structural Ironwork.

See Architectural Engineering, Construction.

Trussed Roof.

See Architectural Engineering, Construction.

Tunnel.

The Simplon Tunnel. Brief account of machines used in the work and methods by which it is hoped to complete this great work in less than contract time. 700 w. U. S. Cons Repts, No. 639—Jan. 27, 1900. No. 32099 D.

The Tunnel Under the Spree, Between Stralau and Treptow, near Berlin (Der Spree-Tunnel zwischen Stralau und Treptow bei Berlin). With plan and profile of the tunnel and illustrations of the method of operating the shield and conducting the work. 1800 w. Glückauf—Jan. 1, 1900. No. 32160 B.

The Turchino Tunnel (Le Tunnel de Turchino). A description of the recently completed tunnel on the Genoa-Ovada-Asti railway, by which connection is made with the Mont Cenis route to Switzerland and France. A profile and sections are given. 2000 w. Génie Civil—Dec. 23, 1899. No. 32104 D.

HYDRAULIC AND MARINE.

Bilbao.

The Port of Bilbao (Puerto de Bilbao). A description of the breakwater, built under royal order of June 29, 1888. It is constructed of stone and cement and situated at the west of the outer harbor, and is 1,450 metres long. Serial, Part I. 3000 w. Revista de Obras Publicas—Dec. 14, 1899. No. 32186 D.

Breakwater.

The Reaction Breakwater as Applied to the Improvement of Ocean Bars. Continued discussion of paper by Lewis M. Haupt. 4200 w. Pro Am Soc of Civ Engs—Jan., 1900. No. 32053 E.

Canals.

Canada's Improved Canal System. On

the canal schemes aiming to divert the trade of the lakes from New York to Montreal. 2000 w. Engng—Dec. 22, 1899. No. 31725 A.

Concerning the Actual Condition of the Panama Canal. Charles Paine. The testimony of an eye-witness as to the advanced condition of the work at Panama at the present time and of the advantage of completing this undertaking rather than the commencement of a new work. With valuable topographical map. 3500 w. Engineering Magazine—Feb., 1900. No. 32191 B.

Opening of the Chicago Drainage Canal. A brief account of the opening on January 2, with short review of the work. 1400 w. Fire & Water—Jan. 6, 1900. No. 31774.

Opening of the Chicago Drainage Canal. Brief account of the letting of the river water into the canal, with outline of the work, and remarks made by Isham Randolph. 1000 w. Eng News—Jan. 11, 1900. No. 31865.

The Canals of Canada. Arthur Weir. From a paper read before the Applied Science Students of McGill University. Canal history and canal engineering. Ill. 4000 w. Can Engr—Jan., 1900. Serial. 1st part. No. 31949.

The Chicago Drainage Canal. Edwin O. Jordan. Brief review of this work, now nearing completion, and questions relating to it. 3000 w. Rev of Revs—Jan., 1900. No. 31756 C.

The Improvement of a Portion of the Jordan Level of the Erie Canal. William B. Landreth. An illustrated description of the difficulties encountered and the methods used in overcoming them. 4700 w. Pro Am Soc of Civ Engs—Dec., 1899. No. 31704 E.

The Transformation of the Lateral Canal of the Loire (Transformation du Canal Latéral à la Loire). E. Rouyer. A full account of this important engineering work, with views of the aqueducts, locks, and bridges. A map and profile of the canal are given, and dimensioned drawings of important details. 2500 w. 1 plate. Génie Civil—Jan. 13, 1900. No. 32-107 D.

Drilling.

Exploration for Bed-Rock at Gila River Dam Sites with Diamond Core Drills. J. B. Lippincott. Illustrates and describes interesting investigations for the purpose of locating sites for reservoirs, thus furnishing water to irrigate the dry lands of Arizona. 2200 w. Eng News—Jan. 18, 1900. No. 31974.

Filters.

A Russian Report on Mechanical Filters. Review of the report made to the Moscow city officials by N. P. Simin, advising the adoption of mechanical filters, and advancing suggestions for their improvement. 800 w. Eng Rec—Jan. 20, 1900. No. 31988.

Test of a Mechanical Filter. Discussion of the paper by Edmund B. Weston. 4000 w. Pro Am Soc of Civ Engs—Dec., 1899. No. 31705 E.

Test of a Mechanical Filter. Continued discussion of paper by Edmund B. Weston. 2700 w. Pro Am Soc Civ Engs—Jan., 1900. No. 32051 E.

Great Lakes.

Report of the Deep Waterways Board on the Regulation of the Great Lakes. An abstract of the conclusions of the Board of Engineers appointed by Congress, as given in a preliminary report. Also editorial comment on this stupendous project for improving lake navigation. 4200 w. Eng News—Jan. 4, 1900. No. 31744.

The Lake Erie Regulating Weir. A description of the barrage which it is proposed to build across the foot of Lake Erie to maintain a fairly uniform depth of water in the Great Lakes. 1200 w. Eng Rec—Jan. 6, 1900. No. 31772.

Incrustation.

The Incrustation of Iron Pipes. Illustrated review of papers before the Inst. of Mech. Engs. on methods of removing tubercles and sediment in iron pipe, with the results of the cleaning on the discharge. 5100 w. Eng Rec—Dec. 30, 1899. No. 31673.

Irrigation.

Irrigation in Jeypore State. Describes the type of heavy earth dams, built where labor alone is cheap, which are afterwards fitted with masonry core walls when they appear necessary. 2200 w. Eng Rec—Jan. 13, 1900. No. 31886.

Laboratory.

The Hydraulic Laboratory of Lafayette College. Illustrated description of a new laboratory for the demonstration of hydraulics before classes, and for experiments by students. 3000 w. Eng Rec—Dec. 30, 1899. No. 31668.

Lead Poisoning.

The Action of Water on Lead, Tin, and Zinc Service Pipes. Facts from H. W. Clark's review of investigations made by the Massachusetts Board of Health. Also short editorial. 1000 w. Eng News—Jan. 4, 1900. No. 31743.

Lift Locks.

The Lift Lock Near Henrichenburg, Germany. Illustrated description of a lock with a lift of 53 ft., which consists of a tank on five vertical floats in deep pits, the motion being regulated by vertical screws driven by electric motors. 1800 w. Eng Rec—Jan. 13, 1900. No. 31885.

Nile.

The Utilization of the Nile. Illustrated

description of the barrages at Assuan and Assuit, designed to pass great volumes of water through sluices if necessary. Also describes a system of cast-iron sheet piling. 1300 w. Eng Rec—Dec. 30, 1899. No. 31672.

Obstruction.

The Location of Pipe Obstructions by Sound. Illustrated explanation of the method of ascertaining the location by the use of a chronograph and pistol shots. 800 w. Eng Rec—Dec. 30, 1899. No. 31671.

Power Canal.

The St. Lawrence Power Plant. Illustrated description of the methods adopted at Massena in cutting a canal about three miles long, for developing 150,000 h.p., with an account of the concrete foundations of the power station. 5000 w. Eng Rec—Jan. 6, 1900. No. 31764.

Purification.

The Purification of Water After Its Use in Manufactories. Two papers read at a meeting of the British Inst. of Civ. Engs. Reginald A. Tatton considered the condition of the Mersey and Irwell watershed; and W. O. E. Meade-King gave an account of experiments to correct the evil. 1200 w. Col Guard—Jan. 19, 1900. No. 32235 A.

Reservoirs.

The Groined Arch as a Covering for Reservoirs and Sand Filters: Its Strength and Volume. Continued discussion of paper by Leonard Metcalf. 800 w. Pro Am Soc of Civ Engs—Jan., 1900. No. 32052 E.

The Wachusett Reservoir. Illustrated description of the methods employed in stripping a basin 8½ miles long, 2 miles wide at one place, and 6.6 sq. miles in area. Also describes a method of sinking 51-ft. sheet piles with a water jet. 4000 w. Eng Rec—Jan. 20, 1900. No. 31986.

Riparian Rights.

The Rights of Riparian Owners. Editorial discussion of the rights and liabilities as affected by the principles of common law relating to surface waters. 3000 w. Engng—Jan. 5, 1900. No. 31926 A.

River Improvement.

The Improvement of the Chicago River Necessary for the Drainage Canal. E. T. Ericksen. Illustrated description of this interesting engineering work. 5200 w. Wis Engr—Jan., 1900. No. 32015 D.

River Pollution.

A National Investigation of River Pollution. A statement of the importance of a national study of the subject and of avoiding irresponsible appeals calculated to cast ridicule on national sanitation. 1000 w. Eng Rec—Dec. 30, 1899. No. 31666.

The End of River Pollution in Connecticut. A statement of the grounds on which the Connecticut Supreme Court has forbidden the pollution of rivers by sewage. 1200 w. Eng Rec—Jan. 20, 1900. No. 31985.

Rivers.

River Hydraulics. Continued discussion of paper by James A. Seddon. 2000 w. Pro Am Soc Civ Engs—Jan., 1900. No. 32054 E.

Settling Basin.

Reinforcement of the Walls of the Kansas City Settling Basins and the Use of a Coagulant to Aid Clarification. W. Kiersted. Illustrated description of the work, and of the method of clarifying now in use. 3000 w. Eng News—Jan. 4, 1900. No. 31742.

Sluices.

Sluices of the Betwa Canal Head and Weir. Robert Macalister. Descriptive. 700 w. Prac Engr—Jan. 12, 1900. No. 32023 A.

Stand Pipe.

Stand-Pipe Failure at Collingswood, N. J. Illustrated description of a failure due to the accumulation of ice in the top of the pipe, which caused a vacuum when the water was drawn down. 350 w. Eng Rec—Jan. 20, 1900. No. 31990.

Stream Regulation.

Stream Regulation by the Use of Piling (Flussverabauung nach dem Pfahlbau-System). A. Schindler. A discussion of a method of regulating and improving the beds of streams by forming an outline of piling to be filled in by the débris. Serial. Part I. 2000 w. Schweizerische Bauzeitung—Jan. 6, 1900. No. 32140 B.

Tides.

A Study of the Action of the Tides in the English Channel (Etude du Régime de la Marée dans la Manche). M. Bourdelles. An exhaustive examination of the channel tides, with hydrographic maps and tables. 15000 w. 2 plates. Ann des Pontes et Chaussées—3 Trimestre, 1899. No. 32118 E + F.

Turbidity.

Silica Standards for the Determination of Turbidity in Water. George C. Whipple and Daniel D. Jackson. Explains the silica method and commends it for its simplicity, uniformity, and accuracy. 1200 w. Tech Quar—Dec., 1899. No. 31844 E.

Waste.

Water Waste. Joseph C. Beardsley. Advocating the use of meters to prevent waste, and giving the experience of Cleveland, O. 3500 w. Jour Assn of Engng Socs—Dec., 1899. No. 32018 C.

Water Power.

The Law of Water and Modern Indus-

try (La Ley de Aguas y las Industrias Modernas). J. Nolla y Ailu. An argument that the increasing use of water power for generating electricity requires a reformation of the law of June 13, 1879, referring to water powers. 3000 w. Revista de Obras Publicas—Dec. 21, 1899. No. 32187 D.

Water Supply.

Melbourne Water Supply. The history of the supply, describing the sources, and the improvements carried out. Ill. 3300 w. Engng—Jan. 5, 1900. No. 31923 A.

The New Croton Dam—New York City's Water Supply. Brief illustrated description of an engineering undertaking which will greatly change the appearance of the Croton valley. 1200 w. Sci Am—Jan. 20, 1900. No. 31956.

The Water Supply of Large Cities. An editorial on the probable return to large streams and ponds as sources of municipal supply, in consequence of the reduced pollution which courts will allow, and of improvements in filtration processes. 900 w. Eng Rec—Jan. 27, 1900. No. 32087.

Waterway.

The Waterway Between Cosel and Breslau (Der Wasserweg zwischen Cosel und Breslau). Jos. Riedel. With diagrams showing the mean height of the Oder at various points; also sections of the river bed and a description of the navigation of the upper Oder. 1500 w. Zeitschr d Oesterr Ing u Arch Ver—Dec. 15, 1899. No. 32114 B.

Water-Works.

The Dresden Water-Works. James H. Fuertes. Illustrated description of some of the largest ground-water works now in service. 10000 w. Eng Rec—Dec. 30, 1899. No. 31670.

The Water-Works of Portland, England. Illustrated description of works drawing a supply from a well with headings run out from it; the covered reservoir is of unusual design on account of its combination of a circular ground plan with barrel-arch roof. 2000 w. Eng Rec—Jan. 13, 1900. No. 31884.

Windmills.

The Homemade Windmills of Nebraska. Erwin Hinckley Barbour. Condensed from Bul. of U. S. Agri. Ex. Station of Neb. The first of a series of illustrated articles showing the invention of Nebaska farmers for furnishing a cheap means of irrigation. 4000 w. Sci Am Sup—Jan. 13, 1899. Serial. 1st part. No. 31847.

MATERIALS.

Beams.

Supports for Beams in Tests of Transverse Strength. William T. Magruder. Presented at meeting of the Am. Assn. for the Adv. of Science. Illustrated description of tests made at the Ohio State Univ. 900 w. Eng News—Jan. 11, 1900. No. 31863.

Cement.

Comparative Tests of Different Forms of Cement Briquettes. Illustrated review of experiments made by H. C. Belcher and Jerome Sondericker fixing certain features of testing apparatus as necessary to obtain comparable results. 2700 w. Eng Rec—Dec. 30, 1899. No. 31669.

Tests of the Constancy of Volume of Portland Cement. A review of the report of the Society of German Portland Cement Manufacturers and the Mechanical Testing Laboratory of the Berlin Technical School on the value of accelerated tests for soundness. 3300 w. Eng Rec—Jan. 20, 1900. Serial. 1st part. No. 31991.

Stresses.

Stresses in Circular Plates. Edward Godfrey. A letter discussing this subject and aiming to show that some of the formulas in use are wrong. 1800 w. Eng News—Jan. 4, 1900. No. 31745.

Timbers.

Physical Tests of Some Pacific Coast Timbers. Frank Soulé. Reports tests of Douglas spruce and California redwood. 1200 w. Trans Am Inst of Min Engs—Sept., 1899. No. 31653 D.

MEASUREMENT.

Surveying.

Hints Upon Transit Surveys, and the Avoidance and Checking of Errors. E. Sherman Gould. Recomends methods tested by practical experience for the avoidance of errors in instrumental work. 3000 w. Eng News—Jan. 4, 1900. No. 31741.

The Rectangular System of United States Public Land Surveying. Charles L. Du Bois. An exposition of the system used, rates, methods, etc. Ill. 6000 w. Tech Quar—Dec., 1899. No. 31843 E.

MUNICIPAL.

Asphalt Pavement.

Failures in Asphalt Pavements. A paper by A. W. Dow on the different influences which will cause the premature destruction of such pavements, and the remedies. 4000 w. Eng Rec—Jan. 6, 1900. No. 31766.

Fire Protection.

Fire Protection. Francis B. Stevens. An account of fires dating back to 1845, illustrating the progress made in means of extinguishing fires, discussing also

systems for pumping salt water. 2500 w. Stevens Ind—Jan., 1900. No. 32-248 D.

Garbage Fuel.

The Utilization of Garbage for Fuel. From the *N. Y. Times*. Letters on this subject by George Westinghouse, R. H. Thurston, and Cary T. Hutchinson. 2200 w. Eng Rec—Jan. 20, 1900. No. 31992.

Power Station.

Municipal Lighting and Sewerage Plant, Concord, Mass. Illustrated detailed description of a small plant as nearly as possible automatic in its operation. 1300 w. Elec Wld & Engr—Jan. 13, 1900. No. 31906.

Refuse.

Refuse and Its Calorific Power. Ed. C. de Segundo. Remarks on investigations made which are considered inadequate for furnishing reliable data. 1700 w. Elec Rev, Lond—Jan. 12, 1900. No. 32030 A.

Sewage.

New Sewage Farm for the St. Denis Ward of Montreal. Illustrated description of a farm of 20.05 acres, which it is expected will care for the sewage of 12,000 people. 800 w. Eng News—Jan. 25, 1900. No. 32072.

Sewage Disposal at Alliance, O. Describes the operation of a plant using chemical treatment and gives the resulting purification attained. 1800 w. Eng Rec—Jan. 13, 1900. No. 31883.

The Problem of Sewage Sludge Disposal. W. L. Hedenberg. Discusses the four general methods of sludge disposal, and their advantages and objections. 3000 w. Munic Engng—Jan., 1900. No. 31700 C.

The Sewerage of Edinburgh, Scotland. James H. Fuertes. Illustrates and describes the novel details of the works and of the method of irrigating with the sewage. 1000 w. Eng Rec—Jan. 13, 1900. No. 31882.

Sewers.

A New Sewer Invert Block. Illustrated description of the block designed by A. N. Talbot to concentrate the minimum flow in a sewer in a channel of small radius. 900 w. Eng Rec—Jan. 6, 1900. No. 31765.

Maintenance of Sewers. Elmer D. Fletcher. Letter giving methods of cleaning by floats, employed at Winchester, Mass. 700 w. Eng Rec—Jan. 27, 1900. No. 32093.

Siam.

Public Improvements in Siam. Concerning the electric light and the streets of Bangkok. 1100 w. U. S. Cons Repts, No. 636—Jan. 24, 1900. No. 32044 D.

Tunnel.

On With the Tunnel. Letter to the editor discussing the problem of more closely uniting the various districts of Greater New York. 1800 w. R R Gaz —Jan. 19, 1900. No. 31977.

MISCELLANY.

Africa.

The Economic Conquest of Africa. H. G. Prout. A forecast of the economic future of Africa, showing the changes which may be expected from the introduction of European methods of exploitation, transport and development. 4000 w. Engineering Magazine—Feb., 1900. No. 32190 B.

Review.

Engineering Review of 1899. Editorial review of all branches of engineering, noting the most prominent feaures, and giving much interesting information. 28500 w. Engr, Lond—Jan. 5, 1900. No. 31921 A.

ELECTRICAL ENGINEERING

COMMUNICATION.

Cables.

An American Pacific Cable. George Owen Squier. Discusses the urgent need of this cable, the routes, practicability, cost, maintenance, operation, etc., giving maps. 7500 w. Trans Am Inst of Elec Engs—Nov., 1899. No. 31955 D.

Breaks in Submarine Cables Close to Repairs. Andrew Gray. Read before the Inst. of Civ. Engs. Considers that, in general, excessive dragging of old cable is the principal cause. 1000 w. Prac Engr—Jan. 12, 1900. No. 32022 A.

India-Rubber as Insulating Material for Cables. Oscar Schaefer. Information on the manufacture of india cores, land cables, and wires, etc. 1300 w. Elect'n, Lond—Jan. 19, 1900. No. 32-225 A.

The Breaking of Cables (Ueber Kabeldurchschlage). Gisbert Kapp. A general review of the causes of break-downs in cables, showing these to be mainly due to the connecting and disconnecting of the conductors in the wrong order; or to the earth contact of the inside conductor, the discussion referring to concentric cables. 6000 w. Elektrotech Zeitschr—Dec. 28, 1899. No. 32166 B.

Transpacific Telegraphy: An Alternative Route. F. R. G. S. Describes a route north through British Columbia

and Alaska to Behring Straits, and connecting with a line to Siberia, discussing the commercial aspect and physical difficulties, and comparing costs. 1200 w. Elec Wld & Engr—Jan. 20, 1900. No. 32007.

Exchange.

The "Bedford" Telephone Exchange, Brooklyn. Illustrated description. 500 w. Elec Wld & Engr—Jan. 20, 1900. No. 32008.

The "Central Energy," Multiple Switchboard Independent Telephone Exchange, Parkersburg, W. Va. Illustrated description of the installation of one of the most modern and complete systems. 700 w. Elec Wld & Engr—Jan. 27, 1900. No. 32097.

The Kinloch Telephone Exchange, of St. Louis, Mo. Illustrated detailed description. Two articles, by Frederick E. Bausch and Frank Clark Cosby, describing the exchange and its operation, and the terminal system and underground and aerial lines. Fully illustrated. 6800 w. Elec Wld & Engr—Jan. 6, 1900. No. 31792.

Mont Blanc.

The Work on Mont Blanc in 1899 (Note sur les Travaux au Mont Blanc en 1899). A communication, by Prof. Janssen to the French Academy describing the successful use of uncovered wires laid directly on the ice for the telegraphic communication. 1200 w. Comptes Rendus—Dec. 11, 1899. No. 32123 D.

Overhead Wires.

The Mechanical Stresses on Overhead Electric Wires (Ueber die Mechanische Beauspruchung Elektrischer Luftleitungen). Max Jüllig. Discussing especially the case in which the poles are of unequal height, and showing by a mathematical examination of the catenary, that the greatest stress is at the highest point of attachment. 4000 w. Elektrotech Zeitschr—Dec. 21, 1899. No. 32165 B.

Space Telegraphy.

Recent Patents for Telegraphing Without Wires (Neue Patente für das Telegraphiren ohne Draht). Especially discussing the later patents of Marconi in regard to the use of transformers and condensers. 2000 w. Elektrotech Zeitschr—Jan. 4, 1900. No. 32169 B.

The Development of Wireless Telegraphy. Patrick B. Delany. A historical review of the developments and discoveries which led up to the practical applications of Marconi, showing the present methods of operation and possible future advances. 3500 w. Engineering Magazine—February, 1900. No. 32197 B.

The History and Present Development of Wireless Telegraphy. Greenleaf W. Pickard. Read at meeting of the Maine Academy of Medicine and Science. 5000 w. Sci Am Sup—Jan. 13, 1900. No. 31846.

Switchboard.

Telephone Switchboard with Levers for Metallic Circuits (Tableau Téléphonique à Leviers pour Lignes Doubles). L. Motillot. Illustrating the Fournaire system, in which lever switches are used instead of the customary jacks. 1200 w. L'Electricien—Jan. 13, 1900. No. 32180 B.

Telegraphy.

Present Day Telegraphy. J. Wright. Notes the various systems in use, and describes the Wheatstone Automatic system. 4200 w. Ind & East Engr—Dec., 1899. No. 31970 D.

Telephone Currents.

The Energy of Telephone Currents. Eugene W. Caldwell. Illustrates and describes experiments made to determine under what conditions a transmitter would give the best results and also to measure the energy. 1700 w. Elec Rev, N. Y.—Jan. 3, 1900. No. 31841 C.

Telephones.

Independent Telephone Development of 1899. H. D. Critchfield. Reports unprecedented progress. 1300 w. W Elect'n—Jan. 6, 1900. No. 31806.

Some Interesting Faults on Telephone Circuits. Describes some interesting faults due to storms, electric light or power circuits, faulty construction and ordinary wear and tear. Ill. 1400 w. Elec Rev, Lond—Jan. 19, 1900. No. 32230 A.

The Dardeau Telephone System (Le Système Téléphonique Dardeau). A special system for use in connection with railway signalling, for multiple circuits, the telephone replacing the Morse telegraph instruments. Two articles. 2000 w. L'Electricien—Dec. 23, 30, 1899. No. 32179 each B.

The Telephone in Sweden. A short account of how the universal use of the telephone has been brought about, and the high degree of development. 1500 w. Engng—Dec. 29, 1899. No. 31832 A.

DISTRIBUTION.

Alternating Currents.

Compensation of Line Drop in Alternating Current Circuits. E. J. Berg. An elucidation of this subject, illustrated by example. 2200 w. Elec Wld & Engr—Jan. 13, 1900. No. 31908.

Converters.

Rotary Field Converters and Rotary Field Transformers (Drehfeld Umformer und Drehfeld Transformator). J. Herrman. A comparison of the apparatus for converting rotary into continuous currents, and also for converting and at the

same time transforming pressure. 2000 w. Elektrotech Zeitschr—Jan. 18, 1900. No. 32174 B.

The Rotary Phase Converter. R. W. Quick. An analysis of the m-to-n phase conversion. 2800 w. Elec Wld & Engr—Jan. 6, 1900. No. 31793.

Insulation.

The Use of Rubber Insulated Wire in Steel Conduits. V. Zingler. Urging either another form of insulation, or a better grade of rubber, when the wires are drawn into metal tubes. 1800 w. Elec Rev, Lond—Jan. 5, 1900. No. 31941 A.

Stray Currents.

Destructive Effects of Vagrant Electricity. Hubert S. Wynkoop. An explanation of the decay called electrolysis and suggestions for overcoming the difficulty. Ill. 2000 w. Ap Pop Sci M—Jan., 1900. No. 31659 C.

Three-Wire.

Three-Wire Distribution from One Machine. Edward Bretch. Explanation of the means for connecting the neutral of a three-wire system into the windings of a direct-current generator, the brushes of which are connected to the positive and negative sides of the system. 1100 w. Elec Wld & Engr—Jan. 13, 1900. No. 31907.

ELECTRO-CHEMISTRY.

Chemicals.

A New Electrolytic Process of Manufacturing Chemicals. A description of the Hargreaves-Bird process as explained in the *Liverpool Post*, with comments. 700 w. U. S. Cons Repts, No. 617—Jan. 2, 1900. No. 31662 D.

Contact.

The Contact v. the Chemical Theory of the Volta Effect. Discusses the controversy on the action of the Volta contact effect, giving the views of prominent experimenters. Ill. 4000 w. Elec Rev, Lond—Dec. 29, 1899. No. 31814 A.

Dissociation.

The Application of the Dissociation Theory to the Electrolysis of Aqueous Solutions (Ueber die Verwendbarkeit dei Dissociations-theorie bei Elektrolyse Wässriger Lösungen). J. G. MacGregor. Discussing the particular case in which two electrolytes and a common ion are used, giving tables of results with a number of solutions. 2500 w. Elektrochem Zeitschr—Jan. 1, 1900. No. 32178 D.

Electrolysis.

Apparatus for Use in Experimental Fused Electrolysis. Alec. A. Beadle. Hints gained fom experience. Ill. 800 w. Elec Rev, Lond—Jan. 19, 1900. Serial. 1st part. No. 32228 A.

Equations.

General Equations of Condition (Allgemeine Zustandsgleichung). R. Mewes. A discussion of the fundamental theoretical equations upon which electrochemical and other chemical relations depend. 3000 w. Elektrochemische Zeitschr—Jan. 1, 1900. No. 32177 D.

Hypochlorites.

The Electrolytic Production of Hypochlorites (Zur Kenntnis der Elektrolytischen Herstellung von Hypochloriten). A. Sieverts. A record and discussion of an extensive series of experiments upon the production of hypochlorites by electrolysis of neutral chloride solution, in the laboratory of the Technical High School at Dresden. Two articles, 5000 w. Zeitschr f Elektrochemie—Jan. 4, 11, 1900. No. 32176 each D.

Ions.

The Heat of Formation of Ions. A. Hollard. Translated from the *Revue générale des Sciences*. Explains method of calculation. 1500 w. Elec Eng, Lond—Jan. 12, 1900. Serial. 1st part. No. 32028 A.

Progress.

Recent Electro-Chemical Progress. C. Knox Harding. Notes on the advances made during 1899. 1200 w. W Elect'n—Jan. 6, 1900. No. 31807.

Review.

The Electro-Chemical and Electro-Metallurgical Industries in 1899. John B. C. Kershaw. A review of progress, some of the industries showing steady advancement, while the calcium carbide industry has been phenomenal in its growth. 2800 w. Elec Rev, Lond—Jan. 5, 1900. Serial. 1st part. No. 31940 A.

Voltaic Cell.

Electrolytic Mechanism of the Voltaic Cell. W. R. Cooper. From a book on "Primary Batteries," soon to be published. Shows the Grotthus hypothesis to be unsatisfactory, and discusses the theories of other investigators in part first. 2200 w. Elect'n, Lond—Jan. 19, 1900. Serial. 1st part. No. 32226 A.

ELECTRO-PHYSICS.

Alternating Currents.

The Symbolic Representation of Double-Vector Products and Alternating Waves in General (Symbolische Darstellung Doppelperiodischer Vektorprodukte und Allgemeiner Wechselstromwellen). C. P. Steinmetz. An elaborate mathematical treatment, giving equations and graphical diagrams as applied to a number of practical cases. Two articles. 7500 w. Elektrotech Zeitschr—Dec. 21, 28, 1899. No. 32163 each B.

Atmospheric Electricity.

The Electrification of the Atmosphere. An account of contributions to this subject made in recent years, and of researches. 3000 w. Engng—Jan. 5, 1900. No. 31922 A.

Hysteresis.

A New Method for Studying Hysteresis Curves in Samples of Iron and Steel. Knut Augström. Abstract translation of paper read before the Konglish Vetenskaps-Akademiens Forhandlingar, in Copenhagen. Describes a method of using cathode rays for experimental research. Ill. 700 w. Elec Rev, N. Y.—Jan. 10, 1900. No. 31900.

Laboratory.

The Powerful Current Plant of the Electro-chemical Laboratory of the Zurich Polytechnic (Die Starkstromanlage im Elektrochemischen Laboratorium des Eidgen. Polytechnikums in Zurich). R. Lorenz. Giving view and plan of the special building, together with illustrations and description of this special laboratory department. 3000 w. Zeitschr f Elektrochemie—Jan. 4, 1900. No. 32-175 D.

Magnetism.

The Influence of Heating Upon the Magnetic Properties of Low Steel Plates (Der Einfluss des Ausglühens auf die Magnetischen Eigenschaften von Flusseisenbleche). Hans Kamps. A detailed account of the results of tests, with tables and graphical diagrams, devoting especial attention to the effects of red heat upon hysteresis and remanence. Two articles, 5000 w. Stahl und Eisen—Dec. 1, 15, 1899. No. 32144 each D.

Phase Differences.

Means of Attaining Larger Phase Differences, and Their Application to Various Measuring Instruments. Johannes Görner. From the *Elektrotechnische Zeitschrift*. Describes arrangements adopted by Hartmann and Braun, of Frankfort a/M. for the construction of instruments in which such displacements of currents or fields are necessary. Ill. 1200 w. Elect'n, Lond—Dec. 22, 1899. No. 31716 A.

Method of Detecting and Equalizing the Period Difference of the Alternating Circuits (Anordnunegn zur Erkennung und Ausgleichung der Periodendifferenz Zweier Wechselstromkreise). W. Ritter, Giving a number of diagrams showing methods of connecting alternators when operated in parallel. 3500 w. Elektrotech Zeitschr—Jan. 4, 1900. No. 32168 B.

The Compounding of Harmonic Vibrations with Fixed Phase Differences. William Hallock. An account of experiments with telephones. 700 w. Elec Rev, N. Y.—Jan. 3, 1900. No. 31840 C.

Radiography.

The Use of Three-Phase Currents in Radiography (De l'Emploi des Courants Triphasés en Radiographie). M. Delézinier. A communication to the French Academy describing the successful use of three-phase currents in connection with the Wehnelt interrupter, for making radiographs. 800 w. Comptes Rendus—Dec. 26, 1899. No. 32124 D.

Resistance.

Variation of Resistance Under Mechanical Pressure. Lawrence Birks. Discusses the results of experiments made by Prof. S. Lussana. 700 w. Elect'n, Lond—Jan. 12, 1900. No. 32026 A.

GENERATING STATIONS.

Bolton Works.

Bolton Corporation Electricity Works. Illustrated description of plant for supplying power to tramways and to the direct-current lighting mains. 2300 w. Elec Rev, Lond—Jan. 19, 1900. No. 32-229 A.

Cambridge, Eng.

Cambridge Electricity Supply Works. Illustrates and describes the work of supplying current for lighting and power in this English university town. 4000 w. Elec Eng, Lond—Jan. 12, 1900. No. 32-027 A.

Chambly.

The Chambly Transmission Plant. E. M. Archibald. An illustrated description of the electrical equipment of the plant. 3000 w. Can Elec News—Jan., 1900. No. 31899.

Costs.

Electricity Supply Works Costs in 1897 and 1898. Tables and useful information. 4000 w. Elect'n, Lond—Jan. 5, 1900. No. 31934 A.

Dynamos.

Recent Papers on the Commutation of the Direct-Current Dynamos. An account of the work done and papers published bearing on this problem. Ill. 2500 w. Elec Rev, Lond—Jan. 12, 1900. Serial. 1st part. No. 32031 A.

The Determination of Defects in Dynamos (Beiträge zur Fehlerbestimmung in Dynamo-maschinen). Karl Richter. A review of Frölich's method, showing the use of the Wheatstone bridge in detecting and locating defects in electric generators. 6000 w. Elektrotech Zeitschr—Jan. 11, 1900. No. 32-172 B.

Garbage Fuel.

See Civil Engineering, Municipal.

Generators.

Electrical Supply and Alternator Design. Alton D. Adams. Advocates the

use of double-current generators to meet the requirements of urban and suburban central-station loads. 2000 w. Elec Wld & Engr—Jan. 27, 1900. No. 32098.

The Factors Which Determine the Design of Monophase and Polyphase Generators. B. A. Behrend. Results of the writer's investigations are given, the present article dealing with the factors which are necessary to predetermine the static characteristic of the alternator. 2000 w. Elec Wld & Engr—Jan. 20, 1900. Serial. 1st part. No. 32004.

Kalamazoo, Mich.

The Kalamazoo Valley Electric Company's Plant. W. G. Fargo and J. B. Foote. Illustrated description of the framed dam, generating station and transmission lines of a plant of 2,000 H. P., serving a district 46 miles long. 2200 w. Eng Rec—Jan. 13, 1900. No. 31880.

Lighting Station.

A Typical Modern Electric Lighting Central Station. Illustrated description of the new high-tension generating plant of the Philadelphia Electric Company. 2800 w. Elec Rev, N. Y.—Jan. 24, 1900. No. 32084.

Petoskey's Lighting Plant. Illustrated description. 1500 w. W Elect'n—Jan. 13, 1900. No. 31950.

Milan.

The Milan Electric Power and Lighting Works. Illustrated description translated from the *Zeitschrift des Vereines Deutscher Ingenieure*. 1300 w. Engr, Lond—Dec. 22, 1899. No. 31730 A.

Niagara.

The Development and Extensions of the Niagara Power System Up to Date. J. E. Woodbridge. Illustrations and information on the most advanced developments of polyphase work. 13000 w. Am Elect'n—Jan., 1900. No. 31796.

The Niagara Falls Hydraulic Power & Manufacturing Company's Plant. Illustrated description of a plant in which the water is received through large penstocks running down the face of Niagara Gorge; the last of these penstocks is 200 ft. high, 11 ft. in diameter and entirely free from supports between its top and bottom. 3000 w. Eng Rec—Jan. 20, 1900. No. 31987.

Parallel Operation.

Parallel Operation of Direct-Coupled Alternators. W. L. R. Emmet. An explanation of a principle of importance in the proper parallel operation of engine-driven alternators. 1200 w. Elec Wld & Engr—Jan. 20, 1900. No. 32005.

Power Stations.

See Civil Engineering, Municipal.
See Street and Electric Tramways.

Review.

Progress of Central-Station Work. Homer E. Niesz. A review of the last year, commenting on the improvements made. 2500 w. W Elect'n—Jan. 6, 1900. No. 31804.

Storage Batteries.

Storage Batteries and Isolated Plants. Alton D. Adams. Discusses the advantages to building owners where electric power is required, by the use of a storage battery. 2800 w. Elec Wld & Engr—Dec. 30, 1899. No. 31684.

Swiss Practice.

Switzerland. An illustrated description of the supply station at Schaffhausen. 1700 w. Elec Eng, Lond—Jan. 5, 1900. No. 31946 A.

Transformers.

A Graphical Treatment of the Effect of Magnetic Leakage on Transformer Regulation. F. G. Baum. Description of method. 1200 w. Elec Wld & Engr—Jan. 13, 1900. No. 31909.

A New Type of Transformer. Illustrates and describes a new type of transformer constructed by the Helios Co., of Cologne, as given in an article by C. P. Feldmann. 700 w. Elec Engr, Lond—Dec. 29, 1899. No. 31813 A.

University Plant.

Electrical Plant of Ohio State University. Burcham Harding. Illustrated detailed description. 1500 w. Elec Wld & Engr—Dec. 30, 1899. No. 31683.

LIGHTING.

Arc Lighting.

Cost of Arc Lighting. H. H. Wait. A communication in discussion of a paper by William Lispenard Robb, on Series Arc Lighting from Constant Current Transformers. 4700 w. Trans Am Inst of Elec Engs—Nov., 1899. No. 31954 D.

Modern Development in Alternating-Circuit Series Arc Lamps. R. Fleming. Read at Milwaukee meeting of the Northwestern Elec. Ass'n. Part first reviews the slow development of arc lighting by means of alternating currents. 1000 w. Elec Rev, N. Y.—Jan. 24, 1900. Serial. 1st part. No. 32085.

Series Arc Lighting from Constant Current Transformers. William Lispenard Robb. A record of the data obtained in the operation of these transformers. Also discussion. 7200 w. Trans Am Inst of Elec Engs—Nov., 1899. No. 31953 D.

The Development of Constant Current Arc Lighting. H. M. Biebel. Read before the Chicago Elec. Assn. Treats of the generators used, and other related subjects. 2700 w. Elec Rev, N. Y.—Jan. 17, 1900. No. 31981.

The Scientific Principles of Public Lighting by Arc Lamps. F. W. Carter. A study of the principles and a discussion of the problem of finding a system of lights to satisfy stated conditions. 1800 w. Elec Rev, Lond—Dec. 22, 1899. Serial. 1st part. No. 31718 A.

Car Lighting.

See Railway Affairs, Equipment.

Electric Light.

Cheap Electric-Light from Gas. Alton D. Adams. Some facts regarding the gas-engine and dynamo plant. 1600 w. Am Arch—Jan. 20, 1900. No. 31984.

Engines.

See Mechanical Engineering, Steam Engineering.

Isolated Plants.

The Electric Lighting of an Hotel. Illustrates and describes an interesting plant in England. 900 w. Elec Rev, Lond—Dec. 29, 1899. No. 31817 A.

Nernst Lamp.

Possibilities of the Nernst Lamp. Frank H. Mason. Brief statement of the advantages and disadvantages. 1200 w. Gas Wld—Jan. 6, 1900. No. 31913 A.

Post-Office.

Lighting and Power Installation of the New Post-Office Department Building, Washington, D. C. J. P. Alexander. Brief illustrated description of an extensive installation. 1100 w. Elec Wld & Engr—Jan. 6, 1900. No. 31794.

Trieste.

Electric Lighting Plant and Street Lamps of Trieste, Austria. Josef Herzog. Brief illustrated description. 400 w. Elec Wld & Engr—Jan. 6, 1900. No. 31795.

MEASUREMENT.

Hysteresis.

The Testing of Hysteresis in Armature Cores. Francis G. Baily. An account of experiments made and results obtained. 1500 w. Elect'n, Lond—Dec. 29, 1899. No. 31820 A.

Indicators.

Notes on Maximum Demand Indicators. Louis J. Steele. Illustrated description of the Halsey maximum demand indicator, stating its advantages. 2500 w. Elec Rev, Lond—Jan. 5, 1900. No. 31936 A.

Resistance.

A Note on the Electrical Resistivity of Electrolytic Nickel. J. A. Fleming. Read before the Royal Society. Reports the result of researches. 1200 w. Elec Rev, Lond—Jan. 5, 1900. No. 31938 A.

Speed Indicator.

Stroboscopic Methods of Determining the Revolutions and Slip of Small Motors, and the Frequency of Alternating Currents. Illustrates and describes methods devised by Dr. G. Benischke, and the apparatus used. 1200 w. Elec Rev, Lond—Jan. 5, 1900. No. 31935 A.

Units.

Our Electric Units; What Shall We Do With Them? J. A. Fleming. Discussion of the advisability of a revision of the system, and suggesting a rational system that the writer considers practical and sound. 2200 w. Elect'n, Lond—Dec. 29, 1899. Serial. 1st part. No. 31821 A.

TRANSMISSION.

Alternate Currents.

Alternate-Current Power Transmissions. C. Du Riche Preller. Considers the distribution of energy and the practical working results as shown in three installations transmitting energy over large areas. Ill. 2000 w. Engng—Jan. 12, 1900. No. 32032 A.

Long-Distance.

San Gabriel Electric Company. An illustrated description of an interesting plant transmitting electric current to Los Angeles, Cal. 2200 w. Engng—Dec. 22, 1899. Serial. 1st part. No. 31722 A.

Protection.

On the Protection of Electric Power Transmissions from Lightning. J. T. Morris. Miller prize paper read at students' meeting of the Inst. of Civ. Engs. Part first gives illustrated descriptions of lightning arresters. 2000 w. Elec Rev, Lond—Jan. 5, 1900. Serial. 1st part. No. 31939 A.

Quarry.

An Electrical Quarry Installation. Illustrated description of an electrical transmission plant for working a quarry in a mountainous district in the Lowlands of Scotland. 700 w. Elec Rev, Lond—Dec. 22, 1899. No. 31719 A.

POWER APPLICATIONS.

Accumulators.

The International Competition of Accumulators (Concours International d'Accumulateurs). The official report of the tests of storage batteries adapted for automobiles as conducted by the Automobile Club de France. 3000 w. L'Electricien—Jan. 13, 1900. No. 32181 B.

The International Competition of Accumulators for Automobile Vehicles. (Concours International d'Accumulateurs pour Voitures Automobiles). A summary of the official report, giving results of tests upon eight forms of accumulators. 1000 w. Génie Civil—Jan. 13, 1900. No. 32109 D.

Clocks.

Electrical Time Service. F. Hope

Jones. Read before the Inst. of Elec. Engs., England. An account of the various inventions connected with electric clocks, with an illustrated description of devices of the writer. 4000 w. Elect'n, Lond—Dec. 22, 1899. Serial. 1st part. No. 31717 A.

Cranes.

Electric Traveling Cranes. Illustrated detailed description of cranes manufactured in England. 2500 w. Engng—Jan. 5, 1900. No. 31925 A.

Electric-Power.

See Mining and Metallurgy, Mining.

Hoisting.

Generators, Motors, and Switching Apparatus for Electric Hoisting Machinery (Generatoren, Motoren. und Schaltapparate für Elektrisch Betriebene Hebezeuge). F. Niethammer. A very elaborate discussion of the arrangement of electrical machinery of cranes, elevators, conveyors and similar apparatus. Two articles. 10000 w. Elektrotech Zeitschr—Jan. 11, 18, 1900. No. 32171 each B.

Mining Plant.

The Electric Plant in the Falck Coal Mines at Bockwa, near Cainsdorf, Saxony (Die Elektrische Anlagé auf dem Steinkohlenwerk Karl G. Falck in Bockwa b. Cainsdorf i. s.). Describing an excellent application of electric power in coal mining, the plant having operated uninterruptedly from its start in September, 1898. The pit is 765 feet deep. 1200 w. Glückauf—Dec. 23, 1899. No. 32157 B.

MISCELLANY.

Accidents.

Death by Electricity. R. H. Cunningham. Researches to determine the cause of death. Experiments were made on the lower animals and the results are stated. Also editorial notes. 3800 w. Elec Wld & Engr—Dec. 30, 1899. No. 31682.

The Cause of Death from Electric Lighting Currents. W. S. Hedley. The writer considers that in some instances death is due to arrested respiration and in others to stoppage of heart action. 1500 w. Elec Rev, Lond—Jan. 12, 1900. No. 32029 A.

Aluminum.

Aluminum and Its Uses and Treatment in Electrical Engineering. J. H. Henderson. Abstract of a paper read before the Manchester Junior Electrical Engineers. Considers its extraction, its use as a conductor, and in the workshop. 1200 w. Prac Engr—Dec. 22, 1899. No. 31713 A.

Exposition.

American Exhibits at the Paris Exposition of 1900. Part first gives an account of the Department of Electricity and Transportation, by James S. Anthony; and the Transportation Exhibits, by George S. Wilkins. 3500 w. Ill. St Ry Jour—Jan. 6, 1900. Serial. 1st part. No. 31803 D.

Electrical Preparations for the Paris Exposition. Illustrates and describes the United States Court of Honor for the exhibit of electrical and mechanical apparatus of a pioneer or historical character. 1400 w. Elec Wld & Engr—Jan. 20, 1900. No. 32003.

Museum.

The Electrical Collections in the Smithsonian Institution and the National Museum. George C. Maynard. The first part of this serial is a brief history of the Smithsonian Institution and its organization. Ill. 1800 w. Elec Rev, N. Y.—Jan. 3, 1900. Serial. 1st part. No. 31842 C.

Review.

American Electrical Progress During 1899. Charles T. Child. A year's history of the development of electrical engineering and industry in the United States. 3500 w. Elec Rev, N. Y.—Jan. 3, 1900. No. 31839 C.

Recent Progress in the Electrical Industries. Henry L. Doherty. Abstract of a presidential address delivered at the convention of the Northwestern Elec. Assn., at Milwaukee. 2000 w. Eng News—Jan. 25, 1900. No. 32078.

GAS ENGINEERING

Acetylene.

Acetylene Gas Considered Commercially. Horace Allen. Discusses the possible reduction of cost by the use of blast-furnace gas in the production of calcium carbide. 1300 w. Elec Rev, Lond—Jan. 5, 1900. No. 31937 A.

On the Products of the Explosion of Acetylene. W. G. Mixter. An illustrated account of experiments made to obtain facts for or against the hypothesis that a sufficient frequency of molecular impacts is requisite to secure spread of explosive change throughout a gas. 2200 w. Am Jour of Sci—Jan., 1900. No. 31702 D.

The Explosive Side of Acetylene. Frederick H. M'Gahie. An account of some cases studied to determine the limits to avoid dangerous or uneconomic conditions. 1700 w. Sci Am—Jan. 6, 1900. No. 31737.

Analysis.

Apparatus for the Analysis of Illuminating and Fuel Gases. George E. Thomas in *Jour. Am. Chem. Soc.* Illustrated description. 1200 w. Am Gas Lgt Jour—Jan. 8, 1900. No. 31780.

The Analysis of Gas Coal. Describes a laboratory method given in a paper by J. G. A. Rhodin. 900 w. Gas Wld—Jan. 13, 1900. No. 32024 A.

Automatic Meter.

Gas Supply by Automatic Meter. H. O. Eldridge. Read before the So. Dist. Assn. of Gas Engs. and Mgrs. Discusses the difficulties, troubles and successes of supply by automatic meters. 2300 w. Gas Engs' Mag—Jan. 10, 1900. No. 32221 A.

Carbide.

The Cost of Calcium Carbide. A discussion showing the advance that has taken place in this business and especially considering conditions in England. 4300 w. Engr, Lond—Dec. 22, 1899. No. 31727 A.

The Cost of Producing Carbide by Different Agencies. Abstract translation of a paper by F. Liebetanz, read before the Acetylene Congress at Buda Pesth. Shows the effect of the cost of power on the cost of production. 3000 w. Jour Gas Lgt—Dec. 26, 1899. No. 31812 A.

Conflagrations.

Gas Conflagrations. From the *N. Y. Evening Post.* On the dangers from gas main leakage, the cause of fires, effects on health, etc. 1000 w. Am Arch—Jan. 27, 1900. No. 32208.

Cyanide.

Dr. Bueb's Cyanide Recovery Process. A review of a communication by Dr. Scharrer, published in the *Journal für Gasbeleuchtung*, with arguments showing that Dr. Bueb's process follows very closely the process used at Beckton. 2000 w. Jour Gas Lgt—Jan. 9, 1900. No. 31961 A.

Exposition.

The Proposed Gas Exhibition and Congress of Gas Engineers at the Paris Exhibition. An outline of the arrangements made, with illustration of the gas pavilion. 1400 w. Jour Gas Lgt—Jan. 16, 1900. No. 32056 A.

Gasholders.

Foundations for Metal Tanks. R. J. Milbourne. Discusses the conditions necessary in the provision of foundations. Ill. 2000 w. Jour Gas Lgt—Jan. 2, 1900. No. 31859 A.

Gas Transmission.

Gas for Light, Heat and Power Transmission. Alton D. Adams. On the expanding field of gas utilization. 1600 w. Am Arch—Jan. 27, 1900. No. 32207.

Gas Works.

Notes on Building Construction in Small Gas-Works. S. B. Langlands. Read before the North of Ireland Assn. of Gas Mgrs. Suggestions concerning site, arrangement and construction of buildings, etc. 1500 w. Gas Engs' Mag—Jan. 10, 1900. No. 32222 A.

Globes.

A Photometric Comparison of Illuminating Globes. Robert B. Williamson and J. Henry Klinck. Illustrated description of tests made with the object of determining the relative merits of various globes for use with the Welsbach incandescent mantle. 1800 w. Jour Fr Inst—Jan., 1900. No. 31869 D.

Nitrogen.

The Recovery of Nitrogen in Coal Distillation. W. Carrick Anderson, and James Roberts. Extract from a paper read before the Scottish section of the Soc. of Chem. Ind. An account of experimental investigations concerning the way nitrogen distributes itself on heating, and obstacles to be overcome. 6000 w. Gas Wld—Jan. 20, 1900. No. 32227 A.

Photometry.

A French Review of Photometry. Review of the address of M. Vautier, president of the Société Technique de l'Industrie du Gaz en France, dealing with photometry in England, Germany, and France. 2700 w. Jour Gas Lgt—Jan. 9, 1900. No. 31960 A.

Pressure.

An Interesting Account of Changed Pressure Conditions in the Gas Supply of Clinton, Iowa. S. M. Highlands. Describes the raising of the pressure on the entire distributing mains with good results. 900 w. Am Gas Lgt Jour—Jan. 15, 1900. No. 31904.

Prices.

A History of Gas Prices in London. Review of a book by Laurence W. S. Rostron, giving also early history of gas supply in London. 1400 w. Jour Gas Lgt—Jan. 16, 1900. No. 32055 A.

Water-Gas.

Water-Gas Plant of the Peoples Company at Buffalo, N. Y. Illustrated description of modern design and construction. 1500 w. Pro Age—Jan. 1, 1900. No. 31692.

The Dellwik-Fleischer Water Gas Process. Describes this process, and claims great economy of production. Ill. 2500 w. Engng—Jan. 26, 1900. No. 32380 A.

MARINE AND NAVAL ENGINEERING

Armament.

The Armament of Our Latest Warships. Illustrations showing the remarkable changes in navy guns during the last fifteen years, with a table showing the ballistics of the 1899 model. 1700 w. Sci Am—Jan. 20, 1900. No. 31957.

Armour.

Armour Plates (Les Plaques de Blindages). L. Baclé. A most exhaustive treatise on the history and development of armour-plate manufacture in Europe and America, with many illustrations. Two articles, 50,000 w. Bull de la Soc d'Encour—Nov., Dec., 1899. No. 32-127 each G.

Tests of Some Recent Krupp Armour Plates (Beschussprohe einger Neueren Kruppschen Panzerplatten). J. Castner. With photographs showing the remarkable resistance of some of the latest specimens of Krupp's hardened nickel-steel plates, tested before the Japanese commissioners. 1200 w. Stahl und Eisen—Dec. 1, 1899. No. 32141 D.

Buoys.

Combined Gas Light and Bell Buoy. Robert M. Dixon. Illustrates and describes a device invented by the writer. 700 w. Stevens Ind—Jan., 1900. No. 32-247 D.

Coaling.

The Problem of Coaling Warships at Sea. Spencer Miller. Illustrating very fully the apparatus which has been successfully tested and favorably reported upon by the United States Government, fully solving this much discussed problem. 3000 w. Engineering Magazine—Feb., 1900. No. 32194 B.

Coaling Station.

The First Coaling Station for the United States Navy. Illustrates and describes the plant at New London, Conn., for the storage and protection of coal, and for handling from store to vessel with rapidity. 900 w. Ir Age—Jan. 18, 1900. No. 31965.

Cruisers.

H. M. SS. "Pegasus" and "Pyramus." Illustrated description of these two vessels, belonging to a class of eleven. They are fitted with express or small-tube boilers. Gives results of the official trials and of the boiler trials. 2700 w. Engng—Dec. 22, 1899. No. 31723 A.

Docks.

See Civil Engineering, Construction.

Engines.

See Mech. Engineering. Steam Engng.

Ferry Boats.

Railway Ferry Boats in Denmark (Eisenbahn-Dampffähren in Dänemark). Giving plans and sections of ferry boats with one and two tracks; also description of landing stage for manipulation of trains. 2500 w. Zeitschr d Ver Deutscher Ing—Jan. 6, 1900. No. 32-113 D.

France.

The French Navy in 1899 (La Marine Française en 1899). A review of the work in progress and laid down in 1899, with a brief notice of the work at the various French yards. 2000 w. Le Yacht—Jan. 6, 1900. No. 32189 B.

Harbor Defence.

The United States Harbor-Defence Vessels. Illustrated description of the Arkansas, one of the four vessels being constructed for the U. S. navy. 1800 w. Engr, Lond—Dec. 29, 1899. No. 31829 A.

Ice Yacht.

A Jib-Headed Mainsail Sloop Ice Yacht. H. Percy Ashley. Illustrates and briefly describes a late design. 300 w. Sci Am Sup—Jan. 6, 1900. No. 31739.

Life Boat.

Twin-Screw Lifeboat for the U. S. Life Saving Service. C. H. McLellan. Describes experiments recently made with a gas engine as motive power with gratifying results. Ill. 1300 w. Marine Engng—Jan., 1900. No. 31810 C.

Life-Saving.

Competition for the Best Life-Saving Device in Cases of Disaster at Sea. The official regulations regarding the competition for the Anthony Pollak $20,000 prize for the life-saving devices. 900 w. Sci Am Sup—Jan. 27, 1900. No. 32-049.

Merchant Marine.

Striking Growth of Germany's Merchant Marine. Frank H. Mason. An interesting review of the progress and development. 3700 w. Marine Rev—Jan. 4, 1900. No. 31755.

Naval Mountings.

Elswick Naval Mountings. Illustrations and descriptions of mountings for quick-fire guns dealt with in Sir Andrew Noble's paper before the Inst. of Naval Architects. 1200 w. Engr, Lond—Jan. 19, 1900. Serial. 1st part. No. 32210 A.

Naval Work.

Naval Work in English Shipyards and Engine Factories in 1899. Review of the construction of warships and their equipment. 2700 w. Engr, Lond—Dec. 29, 1899. No. 31830 A.

Navies.

British and Foreign Navies. Editorial discussion of official figures given in a recent Government return, making a comparison. 2100 w. Engng—Jan. 12, 1900. No. 32033 A.

Rapid Fire.

Ballistic Tests of the Krupp 15-Cm. Rapid-Fire Naval Gun (Ballistiche Augaben über Kruppsche 15-cm. Marine Schnelllade-Kanonen). J. Castner. A comparison between the light and heavy 15-cm. guns, with ballistic tables and an example of the target practice. 1200 w. Stahl und Eisen—Dec. 15, 1899. No. 32-146 D.

Resistance.

Resistance of Ships. William A. Fairburn. Replies to questions asked concerning conclusions reached in an article published Nov. 9, 1899, in this paper. 2500 w. Marine Rev—Jan. 11, 1900. No. 31903.

Rolling.

The Means Adopted for Moderating the Rolling of Ships. W. J. Luke. Abstract of paper read before the Inst. of Engrs. and Shipbuilders, in Scotland. Discusses the utility of bilge keels, experiments made, etc., in part first. 2200 w. Engs' Gaz—Jan., 1900. Serial. 1st part. No. 31871 A.

Sailing Vessels.

The Strength of Spars and Rigging of Sailing Vessels. Remarks the interesting mechanical problems dealing with the strength and efficiency of these structures, and discusses the applied forces in the present article. 2000 w. Engr, Lond—Jan. 5, 1900. Serial. 1st part. No. 31-915 A.

Shear.

100-Ton Shear with Adjustable Boom. From *Le Génie Civil.* Describes a crane of peculiar construction in use in a German shipyard. Ill. 500 w. Eng News—Jan. 25, 1900. No. 32077.

Shipbuilding.

Shipbuilding and Marine Engineering in 1899. The first of a series of articles considering the work of the several districts and firms. 2800 w. Engng—Jan. 5, 1900. Serial. 1st part. No. 31927 A.

Shipbuilding and Marine Engineering in 1899. A review of this industry in the United Kingdom, giving interesting information. 3600 w. Engng—Dec. 29, 1899. No. 31833 A.

Shipbuilding in Germany. An article showing Germany to be second to England in ocean transportation. 900 w. U. S. Cons Repts, No. 638—Jan. 26, 1900. No. 32083 D.

Shipbuilding Plant of the Union Iron Works at San Francisco. An illustrated description of the works where the "Oregon" was built. 2300 w. Marine Engng—Jan., 1900. No. 31808 C.

Sound Steamer.

New Sound Flyer. Illustrated description of the Chester W. Chapin, the latest addition to the New Haven Steamboat Company's fleet. 1600 w. Nau Gaz—Jan. 11, 1900. No. 31890.

Speed Trials.

Official Speed Trials of the 30-Knot U. S. Torpedo Boat Dahlgren. Describes the severe trials which were carried out so successfully. Ill. 2200 w. Marine Engng—Jan., 1900. No. 31809 C.

Steamships.

Great Modern Steamships (Die Reisendampfer der Neuzeit). Oswald Flamm. A description of the development of the large steamers of the last ten years, with illustrations of numerous examples of German vessels, both of the navy and the merchant marine. 3000 w. Stahl und Eisen—Dec. 1, 1899. No. 32142 D.

The Cunard Steamer Saxonia. Describes a large cargo carrier which has excellent passenger accommodations, but is not designed for great speed. 1500 w. Engr, Lond—Dec. 22, 1899. No. 31731 A.

Steam Yacht.

The Humber Steam Pilot Yacht "Commander Cowley." Brief description with illustrations. 500 w. Engng—Dec. 29, 1899. No. 31831 A.

Steel Ships.

New Competitive Conditions in Steel Shipbuilding. Waldon Fawcett. Considers the changes that will come with the opening of the St. Lawrence canals, thus giving a water way for moderately deep draft vessels between the Great Lakes and the coast. 2200 w. Ir Age—Jan. 18, 1900. No. 31968.

Turrets.

Modern Turrets. Illustrated description of several types, and recent improvements in construction. 1200 w. Sci Am Sup—Jan. 20, 1900. No. 31958.

U. SS. Hartford.

Reconstruction of Farragut's Flagship, the U. SS. "Hartford." An account of the daring entrance to Mobile Bay, with illustrations of the vessel before and after reconstruction. 1200 w. Sci Am—Jan. 27, 1900. No. 32046.

Warships.

Warship Construction in 1899. An account of vessels launched from the Royal dockyards and from shipbuilding works, steam trials, etc. 3500 w. Engng—Dec. 22, 1899. No. 31726 A.

MECHANICAL ENGINEERING

AUTOMOBILISM.

Accumulators.

See Electrical Engineering, Power Applications.

Costs.

Operating Costs of Horse and Electric Delivery Wagons in New York City. G. F. Sever and R. A. Fliess. Results of an investigation of comparative expenses as at present instituted by the large department stores in New York. 7500 w. Trans Am Inst of Elec Engs—Nov., 1899. No. 31951 D.

Design.

Design of Automobiles. M. C. Krarup. Discusses the construction and the requirements of the public under the present road and street conditions, offering suggestions. 3500 w. Am Mach—Jan. 4, 1900. No. 31752.

Motor Vehicles. Alex. Craig. Excerpt from a paper read before the Cycle Engs.' Inst., Coventry, Eng. Considers motive power, transmission gear, etc., etc. 3200 w. Automotor—Jan., 1900. No. 32063 A.

The Automobile Movement—Styles of Vehicles Required—Separate Tractors. M. C. Krarup. Discusses the difficulties to be overcome, and the conditions in Europe and the United States. 2300 w. Am Mach—Jan. 25, 1900. No. 32060.

The Automobile Vehicle. Fred. J. Newman. A mechanical description of some of the best American vehicles, discussing the features of different types, and some of the engineering problems. 4000 w. Wis Engr—Jan., 1900. No. 32013 D.

Electric Vehicles.

Electric Automobiles. Elmer A. Sperry. Considers in detail the special features of these vehicles, and their maintenance and operation. Ill. 4400 w. Trans Am Inst of Elec Engs—Nov., 1899. No. 31952 D.

The Manufacture of Electric Automobiles. Illustrated description of methods employed by the Columbia & Electric Vehicle Co., of Hartford, Conn. 3200 w. Elec Wld & Engr—Jan. 13, 1900. No. 31905.

The Mors Carriage. Review of the motor, mechanism and general details of the motor vehicles manufactured by the Société de l'Electricité et Automobiles Mors, Grenelle, France. Ill. 1800 w. Sci Am Sup—Jan. 20, 1900. No. 31959.

Liverpool Traffic.

Heavy Motor Wagons for Liverpool Traffic. Arthur Musker. Read before the Liverpool Engng. Soc. Describes the experience of makers in an effort to make a motor wagon having a tare of 3 tons, to carry loads varying from 5 to 10 tons. 3000 w. Automotor—Jan., 1900. No. 32062 A.

The Liverpool Trials of Motor Vehicles. Summary of the report of the judges who conducted the trials from July 31 to Aug. 2, 1899. Ill. 3800 w. Automotor—Jan., 1900. No. 32061 A.

Local Transit.

The Automobile in Local Transit. Sylvester Baxter. Discusses cab service in large cities, and the motor-omnibus service soon to be installed in some American cities. 2500 w. Auto Mag—Feb., 1900. No. 32205 C.

Motor-Car.

The Gobron and Brillié "Silent" Motor-Car. Illustrated description of the interesting features. 2100 w. Ind & Ir—Dec. 29, 1899. No. 31819 A.

Motor Cycles.

Motor Cycle Racing. Al. Reeves. An illustrated account of the working of these machines and of some of the races in the United States. 1200 w. Auto Mag—Jan., 1900. No. 31690 C.

Motor Horse-Powers.

The Truth About Motor Horse-Powers. Georgia Knap. An explanation of the horse-power of automobile motors, based upon brake tests made and repeated. 3300 w. Auto Mag—Jan., 1900. No. 31691 C.

Motor-Wheel.

Motor-Wheel for Vehicles. Illustrated description of a wheel that may be attached to vehicles and bears much the relation to them that a locomotive does to a train. 500 w. Sci Am—Jan. 6, 1900. No. 31738.

Oil Motor.

Oil Engines and Motor Cars. Anthony G. New. Considers the application of oil engines to motor cars. Part first deals with the car, the engine, and the interaction of car and engine. 4300 w. Engr, Lond—Jan. 5, 1900. Serial. 1st part. No. 31914 A.

Omnibus.

The Purrey Steam Automobile (Automotrice à Vapeur, Système Valentin Purrey). H. Brosselin. A detailed description of the mechanism and operation of the steam omnibus now under practical trial by the Compagnie Genéral des Omnibus of Paris. 7000 w. 2 plates. Rev Gen des Chemins de Fer—Jan., 1900. No. 32137 G.

Postal Service.

Automobile Postal Service. Perry S. Heath. Illustrations of vehicles used and

review of tests made in various cities of the United States and in Europe. 2100 w. Auto Mag—Feb,. 1900. No. 32200 C.

Racing.

Motor Racing. Edwin Emerson, Jr. An interesting illustrated account of vehicles and races, discussing the factor of speed, and the proposed races to be run during the Paris Exposition. 3000 w. Auto Mag—Feb., 1900. No. 32201 C.

Official Time-Keeping Rules. Considers methods and instruments employed, and sources of error. 2500 w. Auto Mag—Feb., 1900. No. 32203 C.

The French Racing Rules. Translation of the racing rules drawn up by the French Automobile Club. 4700 w. Auto Mag—Feb., 1900. No. 32202 C.

Review.

One Year's Progress of Automobilism. Félicien Michotte. A review of the advances made during the year in France. Ill. 1800 w. Auto Mag—Feb., 1900. No. 32204 C.

Steam Carriage.

The "Locomobile" Steam Carriage. Illustrated description of the vehicle, its machinery, and operation. 2000 w. Sci Am—Jan. 27, 1900. No. 32047.

Steam Wagons.

A Short Account of Some Modern Steam Wagons. George A. Burls. Part first discusses the tare limit, power, etc. 2200 w. Prac Engr—Jan. 12, 1900. Serial. 1st part. No. 32021 A.

The Simpson-Bodman Steam Lorry. Illustrated detailed description of a vehicle for transporting heavy goods. 2500 w. Ind & Ir—Jan. 19, 1900. No. 32217 A.

Traction.

The Automobile in Traction. Robert H. Thurston. Reviews the past history and present progress, considering the outlook most promising. Ill. 3500 w. Auto Mag—Jan., 1900. No. 31688 C.

Vehicle Motors.

Motor Vehicles and Their Motors (Die Motorwagen und ihre Motoren). A general review of the motors best adapted for automobile service. The first portion is devoted to electric motors. Serial. Part I. 3000 w. Zeitschr d Ver Deutscher Ing—Jan. 6, 1900. No. 32112 D.

Vehicles.

Horse and Automobile Vehicles for Tramways (Les Voitures Tramways à Chevaux et les Voitures Automotrices). G. Manclère. A detailed description, with drawings, of the present standard horse tramway cars of Paris, and of the Serpollet steam tramway vehicle. 7500 w. 4 plates. Rev Gen des Chemins de Fer—Nov., 1899. No. 32131 G.

Weight.

The Tare Weight of Motor Vehicles. H. Wilcke. Letter to the editor reviewing the leading points connected with this matter from an English point of view. 2200 w. Engng—Jan. 12, 1900. No. 32034 A.

HYDRAULICS.

Laboratory.

See Civil Engineering, Hydraulics.

Mine Water.

The Utilization of Mine Water at Hallstatt (Die Verwerthung der Grubenwässer in Hallstatt). C. Schraml. An account of the manner in which the water from the salt mines is used to supplement the local streams in the dry season in connection with the hydraulic power plant. 3000 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—Jan. 6, 1900. No. 32162 B.

Pumping Engines.

Examples of Pumping Engine Construction (Beispiele aus dem Gebiete des Pump-maschinenbaues). Th. v. Bavier. Illustrating and describing a number of pumping engines of recent construction for use in German cities and mines, giving especial attention to those with mechanically actuated pump-valves. 4000 w. 2 plates. Zeitschr d Ver Deutscher Ing—Jan. 6, 1900. No. 32111 D.

MACHINE WORKS AND FOUNDRIES.

Apprenticeship.

Modern Apprenticeship Conditions. John E. Sweet. From an address before the manufacturers and mechanics of Rochester, N. Y. Considers the training of the schools and of the shops, and the duties of employers and employees. 4500 w. Ir Trd Rev—Jan. 18, 1900. No. 31982.

Boiler Shop.

See Architectural Engineering, Heating.

Bushing.

Bushing a Locomotive Cylinder. General description of the work, with illustrations. 1500 w. Mach, N. Y.—Feb., 1900. No. 32253.

Compensation Act.

The Definition of a "Factory" and the Workmen's Compensation Act. Shows how the absence of a definition for the word factory has given rise to many difficulties since this act first became law. 2700 w. Engr, Lond—Dec. 29, 1899. No. 31827 A.

Compressors.

Compound or Two-Stage Air Compressors. Robert Peele. On the advantages of stage compression, and the rise and construction of the intercooler. 2600

w. Mines & Min—Jan., 1900. No. 31-857 C.

The Air Compressor. O. G. Smith. A brief statement of the important features in the process of compressing air, and how it is accomplished in the design of air compressors. 1400 w. Ir & Coal Trds Rev—Dec. 22, 1899. No. 31721 A.

Cranes.

See Electrical Engineering, Power Applications.

Designing.

Economy in Design—Employment of Gravity. W. H. Booth. Calls attention to the advantages secured by utilizing the law of gravity. 1500 w. Am Mach—Jan. 25, 1900. No. 32058.

Drafting-Room.

A Model Drafting Room. Illustrates and describes a convenient arrangement with novel features. 1500 w. Mach, N. Y.—Jan., 1900. No. 31687.

A Modern Drafting Room. Illustrated description of a room in which the heating, lighting and ventilation are special features. 1200 w. Mach, N. Y.—Feb., 1900. No. 32249.

The New Drawing Office of the Schenectady Locomotive Works. Illustrated description of an office representing the best facilities. 1500 w. Am Mach—Jan. 18, 1900. No. 31963.

Drilling.

A Duplex Drill Jig for a Multiple Spindle Driller. D. E. MacCarthy. Illustrated description of a tool recently designed by the writer. 400 w. Am Mach—Jan. 11, 1900. No. 31861.

Drill.

4½-Foot Semi-Universal Radial Drill. Illustrated description of a machine intended for drilling and boring. 300 w. Am Mach—Jan. 4, 1900. No. 31751.

Emery Wheel.

The Plant of the Norton Emery Wheel Company. An illustrated account of these works and things seen there. 1600 w. Am Mach—Jan. 25, 1900. No. 32059.

Enameling.

Enameling Cast Iron. J. Vollkommer. Part first considers the nature of enamels, the preliminary preparations, cleaning and pickling, slush or first coat, and fusing. 2300 w. Met Work—Jan. 13, 1900. Serial. 1st part. No. 31877.

Engine Works.

The New Works of the Harrisburg Foundry and Machine Works. Illustrated description of a plant designed to allow all branches of an engine-building industry to be carried out in a single building as far as possible. The arrangements to meet this aim, and the progress of the work from department to department, are explained in detail. 2500 w. Eng Rec—Jan. 27, 1900. No. 32088.

Fitting.

Lining of Shoes and Wedges. W. D. Chamberlin. An illustrated article giving details of a method for this work. 2500 w. Loc Engng—Feb., 1900. No. 32241 C.

Gears.

Some Points About Cutting Spiral Gears—A Special Spiral Gear Cutting Machine. A. L. de Leeuw. Briefly considers methods of cutting, and related subjects, and gives an illustrated description of a machine built at the Niles Tool Works. 3500 w. Am Mach—Jan. 11, 1900. No. 31862.

Guns.

Guns of Position and Siege Guns for the War. Illustrated description of two 4.7-in. quick-firing guns, and remarks on the conditions in South Africa. 1000 w. Engr, Lond—Jan. 5, 1900. No. 31918 A.

Hoisting.

See Electrical Engineering, Power Applications.

Joints.

Shrink and Press Fits. Henry Hess. Discussion from both theoretical and practical standpoints. 2200 w. Mach, N. Y.—Jan., 1900. No. 31686.

Piece Work.

Piece Work and Premium Plan. R. T. Shea. Opposed to the premium plan, and favoring piece work. Also editorial. 2500 w. Loc Engng—Jan., 1900. No. 31-677 C.

Premium System.

Actual Experience with the Premium Plan. H. M. Norris. Mr. Norris's concluding paper discloses the attitude and policy of American organized labor as opposed to the introduction of any competitive wage system, whereby the return to the workman is based upon his individual effort. 3500 w. Engineering Magazine—Feb., 1900. No. 32192 B.

Screw Machines.

A Lag-Screw Cutting Machine. An illustrated description of an interesting machine designed for cutting screw-threads upon lag-screws. 1200 w. Am Mach—Jan. 25, 1900. No. 32057.

Multiple Spindle Automatic Screw Machine. Illustrates and describes the Acme machine and the work produced. 2000 w. Am Mach—Jan. 18, 1900. No. 31962.

Screw Threads.

Metric Screw Threads. Henry Harrison Suplee. Statements showing that it is not necessary to equip American lathes with metric lead screws, nor to attempt

to produce standard metric dies and taps. 600 w. Mach, N. Y.—Feb., 1900 No. 32251.

Screw Pitches in Foreign Countries. Data upon the pitches of screws used abroad and the gearing for cutting them. 1600 w. Mach, N. Y.—Feb., 1900. No. 32250.

The Standardization of Screw Threads. A summary of information presented in a paper by Signor A. Galassini, and supplemented by facts from other sources. 2800 w. Engng—Jan. 19, 1900. Serial. 1st part. No. 32214 A.

Shop Practice.

Novel Examples of Drill Feeds and Epicyclic Gearing. Illustrated description. 1700 w. Mach, N. Y.—Feb., 1900. No. 32252.

Some Interesting Notes Taken in the Shops of the Arthur Company, New York. Illustrated description of interesting tools and appliances, and of model work. 2000 w. Mach, N. Y.—Jan., 1900. No. 31685.

The Most Perfect Machine Shop. S. D. V. Burr. Illustrated detailed description of Building No. 16 of the Schenectady Works of the General Electric Co. 4000 w. Ir Age—Jan. 4, 1900. No. 31746.

The Revolution in Machine-Shop Practice. Henry Roland. A discussion of the application of automatic mechanical production to heavy work, especially in respect to the elimination of skilled labor in adjustments and accuracy of relative position of parts. 4000 w. Engineering Magazine—Feb., 1900. No. 32196 B.

Tools.

A Portable Drilling Tool with Suction Support. E. P Buffet. From *Génie Civil.* Illustrated description of a portable drill for use in shipyards, invented by M. L. Moissenet. 800 w. Am Mach—Jan. 18, 1900. No. 31964.

A Tap-Threading Lathe, Threading Tool and a Grooving Fixture. Illustrated description of tools. 1000 w. Am Mach—Jan. 4, 1900. No. 31753.

MATERIALS OF CONSTRUCTION.

Carborundum.

Making Carborundum. Sturgis B. Rand. Extracts from *McClure's Mag.* Description of the hottest heat known to man and its practical uses at Niagara Falls. 3500 w. Am Mfr & Ir Wld—Jan. 25, 1900. No. 32064.

Cast Iron.

Testing Cast Iron for Ultimate Stresses. Walter J. May. Showing the results to be only comparative, and suggesting experimental work to determine the relation of test bars to large castings. 1200 w. Prac Engr—Jan. 5, 1900. No. 31912 A.

Cast Steel.

Blacksmith Shop Study of Cast Steel. G. F. Hinkens. From a paper read before the North-West Ry. Club, U. S. A. On the treatment in tool making, the hardening and tempering, etc. 3400 w. Prac Engr—Jan. 5, 1900. No. 31910 A.

Curved Plates.

The Thickness and Form of Curved Sheet-Iron Plates (Sur l'Epaisseur et la Forme à Donner aux Tôles Embouties). Maurice Levy. An analytical and graphical investigation into the resistance of curved plates of various forms and thicknesses; applicable to boiler construction and similar work. 5000 w. Génie Civil—Dec. 30, 1899. No. 32106 D.

Investigations into the Stresses and Deformations of Curved Plates (Untersuchungen über die Formänderungen und die Anstrengung Gewölbter Böden). C. Bach. A very complete record of measurements made upon convex and concave cylinder-heads of wrought and cast iron, giving tabulated and graphical results. Two articles, two plates. 10,000 w. Zeitschr d Ver Deutscher Ing—Dec. 23, 30, 1899. No. 32110 each D.

Extensometer.

A New Extensometer. William H. Kenerson. Illustrates and describes an instrument designed by the writer, used in the testing laboratory of Brown Univ., Providence, R. I. 700 w. Eng News—Jan. 25, 1900. No. 32079.

India-Rubber.

Substitutes for India-Rubber. H. L. Terry. A general discussion of the value of these substitutes as compared with india-rubber. 2000 w. Elect'n, Lond—Dec. 29, 1899. No. 31822 A.

Testing.

Testing the Strength of Materials. Edward F. Miller. Part first deals with tension and transverse tests. Ill. 2500 w. Mach, N. Y.—Feb., 1900. No. 32254.

POWER AND TRANSMISSION.

Cables.

Notes on the Life of Steel Wire Cables. Frank Soulé. An account of tests to be made by E. H. Benjamin, to determine the effects of rust, age, wear and tear, shocks, etc. 700 w. Trans Am Inst of Min Engs—Sept., 1899. No. 31651 D.

Clutches.

Some Types of Friction Clutches. Gives the summary of the essential conditions of a clutch as given by Walter Bagshaw, discussing their uses and things to be considered before buying. Also gives illustrated descriptions of various types. 4200 w. Ir & Coal Trds Rev—Jan. 12, 1900. No. 32040 A.

Coaling.

See Marine Engineering.

Compressed Air.

Discharge of Air from Pipes under Heavy Losses of Pressure. William Cox. A valuable mathematical discussion, with numerous examples showing the practical applications of the methods of computation, also useful tables. Serial. Part I. 1200 w. Compressed Air—Jan., 1900. No. 32352.

Gas Transmission.

See Gas Engineering.

Material Transport.

See Mining and Metallurgy, Iron and Steel.

Ropes.

See Mining and Metallurgy, Mining.

Speed Indicator.

See Electrical Engineering, Measurement.

SPECIAL MOTORS.

Blowing Engine.

Blast Furnace Gas Blowing-Engine at Differdingen (Hochofengasgebläse für Differdingen). Brief description with photograph of a large blowing engine with gas-engine power cylinder operated by blast furnace gases, as recently erected at Differdingen. 500 w. Stahl und Eisen—Jan. 1, 1900. No. 32150 D.

Diesel.

The Diesel Motor (Le Moteur Diesel). C. Lambotte. A general discussion and criticism of the Diesel motor, comparing its performance with that of other internal combustion motors. 5000 w. 1 plate. Rev Univ des Mines—Dec., 1899. No. 32130 G.

The Diesel Oil Engine. An illustrated description of the theory and construction of the Diesel engine, and related information. 4800 w. Engng—Jan. 5, 1900. No. 31924 A.

Gas Engines.

Blast-Furnace Gas for Gas Engines. A review of reports on the subject in various publications. 2400 w. Eng Rec—Jan. 6, 1900. No. 31769.

Gas Engine Governing and Economy. W. H. Booth. Considers the methods of governing gas engines and the advantages of each. 900 w. Am Mach—Jan. 4, 1900. No. 31775.

Oil Motors.

Test of English Oil Engines. Brief report of trials made of ten motors at full brake load, half load, and light load, in which nine proved successful. 500 w. Am Mfr & Ir Wld—Jan. 18, 1900. No. 31972.

See Automobilism.

Vehicle Motors.

See Automobilism.

STEAM ENGINEERING.

Blower System.

See Architectural Engineering, Heating.

Blowing Engines.

Blowing Engines for the National Steel Company. Illustrated description of three interesting engines recently installed at the Ohio works. They are of the inverted marine type, with the air cylinders tandem to and above the steam cylinders. 600 w. Power—Jan., 1900. No. 31790.

Boiler Explosion.

Boiler Explosion at Sheffield. An account of the disastrous explosion on Nov. 1, at the Don Cutlery Works, and the investigation. 4500 w. Engng—Dec. 29, 1899. No. 31834 A.

Boiler Rating.

See Architectural Engineering, Heating.

Boilers.

Circulation in Steam Boilers. Editorial discussion of statements made in a paper by George Halliday, on "The Influence of Velocity on Evaporation in Tubes." 2500 w. Eng News—Jan. 18, 1900. No. 31976.

Commercial Types of Water-Tube Boilers Built in America. Part first illustrates and describes the Almy, Seabury and Niclausse boilers. 2000 w. Marine Engng—Jan., 1900. Serial. 1st part. No. 31811 C.

See Architectural Engng., Heating.

Chimney.

The Monumental Chimney of the Suffren Power House (La Cheminée Monumental de l'Usine Suffren). G. Leugny. A detailed description of the great chimney for the Power-house of the Paris Exposition, with numerous views showing successive stages of the construction. 2000 w. Revue Technique—Dec. 25, 1899. No. 32117 D.

Circulation.

The Dubian Emulseur (Note sur l'Emulseur Dubian). M. Delbrouck. Giving data and results of tests made upon boilers provided with the Dubian circulating device, showing the advantages of a vigorous circulation. 4000 w. 2 plates. Rev Univ des Mines—Dec., 1899. No. 32129 G.

Efficiency.

Investigations Upon the Increase of the Thermal Efficiency of Steam Engines (Versuche zur Erhöhung des Thermischen Wirkungsgrade der Dampfmaschen). A review of the studies of Professor Josse, of Berlin, with details of the investigations, and indicator diagrams from the 40 h.p. experimental engine. 2500 w. Glückauf—Dec. 16, 1899. No. 32154 B.

Engines.

Horizontal Tandem Steam Engine (Horizontale Tandem-Dampfmaschine). Brief description of an 800 h.p. horizontal tandem compound engine, arranged with low-pressure cylinder nearest the crank-shaft. A modified Corliss valve gear is used. 600 w. 1 plate. Stahl und Eisen—Dec. 15, 1899. No. 32147 D.

Large Electric Light Engines. R. D. Summerfield. Considers the types most used, aiming to give a general idea of the direction in which the makers are trending, and his opinion as to which type will survive. 2500 w. Elec Eng, Lond—Jan. 5, 1900. No. 31945 A.

Marine Engines (Les Machines Marines). L. E. Bertin. A very full review of modern marine engine practice, both merchant and naval, with many illustrations and diagrams. 18000 w. Bull de la Soc d'Encour—Oct., 1899. No. 32126 G.

Sulzer Triple-Expansion Engines for the Berlin Municipal Electric Lighting System. Translated from the *Schweizerische Bauzeitung*. Drawings and description of vertical two-crank engines with the cylinders arranged steeple-fashion. 900 w. Eng News—Jan. 25, 1900. No. 32076.

The Evolution of the Stationary Steam Engine. Andrew Robert Robertson. Contributed to the Inst. of Civ. Engs., England. Showing that the main features and principle of the engine as laid down by Watt differ only in detail from those employed by successive experimenters and designers. 4200 w. Col Guard—Dec. 29, 1899. No. 31837 A.

2000 I.H.P. Compound Mill Engines. Illustrated description of an improved type of compound engines in favor where large power is required. 1800 w. Engr, Lond—Jan. 12, 1900. No. 32041 A.

Feed Water.

Corrosive and Incrusto-Corrosive Waters in Steam Boilers (Eaux Corrosives et Incrusto-Corrosives dans les Générateurs de Vapeur). H. de la Coux. An exhaustive discussion of the corrosive action of the various waters met in practice, together with the best methods of relief. Three papers, 6000 w. Génie Civil—Dec. 23, 30, 1899, Jan. 6, 1900. No. 32103 each D.

Firing.

Mechanical Devices as Applied to Firing Steam Boilers. W. E. Snyder. Considers various devices, giving the results of experience. 8000 w. Pro Engs' Soc of W Penna—Dec., 1899. No. 31889 D.

Garbage Fuel.

See Civil Engineering, Municipal.

Heat Losses.

A Complete Heat Cycle for the Steam Boiler and Engine. L. C. Auldjo. Read before the Engng. Assn. of New South Wales. Describes tests made and gives results brought about by the use of this heat cycle. 2500 w. Ind & Ir—Dec. 29, 1899. No. 31818 A.

Hot Water.

See Architectural Engineering, Heating.

Indicator Diagrams.

The Influence of the Indicator Diagram on the Design of Valve Gear. Considers that ingenuity, time and money have been wasted in efforts to obtain a diagram of a particular type, and the object is not worth the cost. 3200 w. Engr, Lond—Jan. 19, 1900. No. 32209 A.

Mechanical Draft.

The Influence of Mechanical Draft Upon the Ultimate Efficiency of Steam Boilers. Walter B. Snow. A brief description of the apparatus and methods employed is given, and the factors on which the efficiency depends are discussed, showing beneficial results. Ill. 4500 w. Jour Assn of Engng Socs—Dec., 1899. No. 32017 C.

Piping.

Power Plant Piping and Accessories. William D. Ennis. Considers the principles of design and discusses the high pressure steam pipes, in the present article. Ill. 3000 w. St Ry Rev—Jan. 15, 1900. No. 31998 C.

Pressure.

Table Showing the Loss of Pressure in Steam Pipes. A. F. Nagle. 250 w. Eng News—Jan. 25, 1900. No. 32073.

Steam Power.

The Economical Generation of Steam Power. B. A. Tapp. Considers some of the recent devices for improving the efficiency. 1800 w. Elec Eng, Lond—Jan. 5, 1900. Serial. 1st part. No. 31947 A.

Superheating.

The Production and Utilization of Superheated Steam. R. S. Hale. A study of the modern devices for superheating steam, and the best methods of applying it in order to realize the highest economy. 3000 w. Engineering Magazine.—Feb., 1900. No. 32195 B.

Valve Motion.

Mistakes in Designing Valve Motion. H. Rolfe. Enumerates disadvantages met, and points needing correction. 1400 w. Loc Engng—Jan., 1900. Serial. 1st part. No. 31676 C.

Winding Engines.

See Mining and Metallurgy, Mining.

MISCELLANY.

Liquid Air.

A Liquid Air Plant. Illustrates and describes the plant of Ostergren & Berger,

New York City, the machinery, process, etc. 2000 w. Ice & Refrig—Jan., 1900. No. 31675 C.

Mathematics.

Mathematics in the Mechanical Trades. J. S. Plaskett. Read at Univ. of Toronto. Shows the advantage of a mathematical training and outlines a course that should be given. Ill. 2800 w. Can Engr—Jan., 1900. No. 31948.

Mechanical Progress.

The Progress in the Mechanical Arts in Three-quarters of a Century. Coleman Sellers. An address delivered at the National Export Exposition on the occasion of the celebration of the 75th anniversary of the Franklin Inst. 7200 w. Jour Fr Inst—Jan., 1900. No. 31868 D.

Patents.

An Important Patent Decision. Arthur F. Kinnan. A criticism on a decision rendered by the United States Court of Appeals for the Dist. of Columbia, in the case of Bechman vs. Wood. 2800 w. Elec Wld & Engr—Jan. 20, 1900. No. 32006.

Planimeter.

The Lippincott Planimeter. A. G. Greenhill. Illustrated description of the instrument and its use. 1800 w. Engr, Lond—Dec. 22, 1899. No. 31728 A.

Printing.

Recent Advances in the Graphic and Photographic Arts (Ueber einige Neuere Arbeiten im Geibeite der Graphischen Künste und der Photographic). Ottomar-Volkmar. Describing especially improved methods of photo-engraving and printing from aluminum plates, with illustrations of presses. 4000 w. Zeitschr d Oesterr Ing u Arch Ver—Dec. 22, 1899. No. 32115 B.

Refrigeration.

European Refrigerating Practice. A. J. Wallis-Tayler. Part first describes the Yaryan system of distilling apparatus. Ill. 1100 w. Mod Mach—Jan., 1900. Serial. 1st part. No. 31661.

Mechanical Refrigeration. Otto Luhr. Gives a brief description of the essentials of the system, and the principles of operation. 3200 w. Power—Jan., 1900. No. 31791.

Review.

A Look Back and a Glance Forward. An interesting review of changes during the last century, and remarks on the possibilities of the future. 1800 w. Eng & Min Jour—Jan. 13, 1900. No. 31891.

Shield.

Devices for Attacking Trenches. Illustrated description of a steel shield made to be used on a rifle or to build up defence. 1600 w. Engr, Lond—Jan. 12, 1900. No. 32042 A.

MINING AND METALLURGY

COAL AND COKE.

Analysis.

On the Determination of Volatile Combustible Matter in Coke and Anthracite Coal. Richard K. Meade and James C. Attix, in *Jour. Am. Chem. Soc.* Describes an investigation looking toward a more satisfactory method of determining volatile combustible matter. 2500 w. Am Gas Lgt Jour—Jan. 8, 1900. No. 31779.

See Gas Engineering.

Coal Pits.

The Ocean Coal Company's Deep Navigation Pits at Treharris. An illustrated account of these Welsh collieries, and of recent improvements. 5000 w. Ir & Coal Trds Rev—Jan. 19, 1900. No. 32219 A.

Coal Production.

Coal in 1899. Reports for the year showing the largest output on record, and giving interesting information. 9800 w. Eng & Min Jour—Jan. 6, 1900. No. 31788.

Coke.

Natural Coke of the Santa Clara Coal-Field, Sonora, Mexico. E. T. Dumble. A description of deposits of interest and value. 1400 w. Trans Am Inst of Min Engs—Sept., 1899. No. 31652 D.

Coking.

The Hemingway Coking Process. Illustrates and describes a process for coking low-grade Western coal. 1400 w. Ir Age—Jan. 18, 1900. No. 31967.

Compensation.

The Workmen's Compensation Act in Relation to Collieries. Statements based upon information gathered from leading insurance officials and other authorities, respecting the operation of this act as regards collieries. 1400 w. Col Guard—Jan. 12, 1900. No. 32039 A.

Indiana.

Coal Mining in Indiana. George H. Ashley. Abstracted from the annual report of the Dept. of Geol. and Nat. Resources of the State of Indiana. Illustrated description of the methods used for haulage and ventilation and for preparing the coal for market. 3800 w. Mines & Min—Jan., 1900. No. 31850 C.

New Zealand.

Notes on the Coalfields of New Zealand. James Park. Read before the Inst. of Min. and Met., London. Concerning the physical character and composition, and an estimate of quantity. 2000 w. Col Guard—Dec. 29, 1899. No. 31836 A.

South Africa.

The Vereeniging Collieries. An illustrated description of this important industry of South Africa. 2800 w. Ir & Coal Trds Rev—Jan. 5, 1900. No. 31933 A.

Thin Seams.

Winning the Seams in the Dortmund Coalfield. From a communication to *Glückauf*. Illustrates and describes a method of working out the coal with gobbing the spaces. 1700 w. Col Guard—Jan. 12, 1900. No. 32036 A.

Trade.

Notes on Foreign Coal and Coke Trades in 1899. Notes on the trade of Germany, France, Belgium, Austria-Hungary, New Zealand, etc. 4800 w. Ir & Coal Trds Rev—Jan. 5, 1900. No. 31932 A.

The Coal and Coke Trades in 1899. A general review and also articles by able writers reviewing various districts of Great Britain. Maps. 11500 w. Ir & Coal Trds Rev—Jan. 5, 1900. No. 31931 A.

The Coal Trade in 1899. Discusses each of the districts in Great Britain, and reports general prosperity. 11200 w. Col Guard—Jan. 5, 1900. No. 31928 A.

COPPER.

Arizona.

The Copper Queen Mine, Arizona. James Douglas. An illustrated description of the deposits and their working, with account of the discovery of the mine and other information. 8500 w. Trans Am Inst of Min Engs—Feb., 1899. No. 31655 D.

Formation.

Notes on the Formations of Copper "Trees" and "Nodules." Sherard Cowper-Coles. Illustrates and describes formations of electro-deposited copper, discussing the causes. 400 w. Elect'n, Lond—Dec. 22, 1899. No. 31714 A.

Production.

Copper in 1899. Information concerning the production, with reports of the New York and London copper markets. 7000 w. Eng & Min Jour—Jan. 6, 1900. No. 31782.

Copper Production and Values. Editorial review of the copper situation. 1800 w. Engng—Jan. 19, 1900. No. 32216 A.

The Copper Industry. Reviews the developments of 1899 and the future outlook. 2300 w. Ir Age—Jan. 4, 1900. No. 31750.

Standards.

Proposed Standards for Copper Specifications. Gives the report of the committee appointed to determine a standard for copper conductors, with editorial comment. 2800 w. Elect'n, Lond—Dec. 22, 1899. No. 31715 A.

Superior.

Lake Superior Copper Mines. Dwight E. Woodbridge. Information concerning the output of the older mines and the great development of the new ones during the past year. 2200 w. Mines & Min—Jan., 1900. No. 31853 C.

GOLD AND SILVER.

British Columbia.

The Progress of Mining in British Columbia During 1899. A general review which is most encouraging. 1500 w. B. C. Min Rec—Jan., 1900. No. 31943 C.

California.

California Mining. Arthur Lakes. Gives the history of mining in the Nevada City and Grass Valley regions, with description of the geology of the veins. Ill. 3500 w. Mines & Min—Jan., 1900. No. 31851 C.

Cape Nome.

Some Notes on Nome, Alaska. Paul F. Travers. An account of the discovery, and of the present outlook and conditions. Ill. 1200 w. Eng & Min Jour—Jan. 27, 1900. No. 32094.

The Cape Nome Gold Fields. Concerning the gold discoveries reported, with tables giving market quotations, and other information. 800 w. U. S. Cons Repts, No. 633—Jan. 20, 1900. No. 31983 D.

Colorado.

Cripple Creek, Colorado, Mines in 1899. Notes on the mining progress. 1200 w. Eng & Min Jour—Jan. 13, 1900. No. 31897.

Gilpin County, Colorado, Mines in 1899. Shows a very prosperous year, and gives information of interest. 1200 w. Eng & Min Jour—Jan. 13, 1900. No. 31895.

Leadville, Colorado, Mines in 1899. Comments on the general conditions of mining during the year. 1800 w. Eng & Min Jour—Jan. 13, 1900. No. 31896.

The La Plata Mountains of Colorado. Arthur Lakes. An illustrated description of the telluride veins and the Mancos Contact. 2700 w. Mines & Min—Jan., 1900. No. 31856 C.

Cyanide.

The Cyanide Plant of the Rose Gold

Mining Company at Victor, California. Charles T. Arkins. Brief illustrated description. 600 w. Eng & Min Jour—Jan. 13, 1900. No. 31893.

Cyaniding in New Zealand. James Park. Describes the geological conditions of the Hauraki peninsula and the treatment of the ores. 5500 w. Trans Am Inst of Min Engs—Sept., 1899. No. 31654 D.

Distribution.

The Wide Distribution of Gold. Arthur Lakes. New and unexpected formations in which it is often found, and why new districts are not often discovered. 1600 w. Mines & Min—Jan., 1900. No. 31-849 C.

Dredging.

Dredging: Its Present and Future Outlook. J. G. Hyde. From the inspecting engineer's report. Considers the chief difficulties to be overcome, and improvements needed. 1000 w. N. Z. Mines Rec—Nov. 16, 1899. No. 31707 B.

The Origin and Progress of Gold Dredging in New Zealand. W. H. Cutten. A fully illustrated paper showing the methods of operating the gold dredging apparatus in the waters of New Zealand, and the wonderfully rich results which have been obtained. 3000 w. Engineering Magazine—Feb., 1900. 32-193 B.

The Waiau River as a Gold-Dredging Channel. Ro. Carrick. Gives a description of dredging ground peculiar to this basin. 1600 w. N. Z. Mines Rec—Nov. 16, 1899. No. 31708 B.

Klondike.

A Year's Progress in the Klondike. Angelo Heilprin. An interesting illustrated description of the improvements in Dawson, and in means of communication with the outside world, the mining outlook, etc. 2800 w. Ap Pop Sci M—Feb., 1900. No. 32016 C.

The Economics of the Klondike. Jack London. Considers the profits and losses of the rush to this region, and what the ultimate outcome will be. Ill. 2500 w. Rev of Revs—Jan., 1900. No. 31757 C.

Production.

Gold and Silver in 1899. An estimate of the gold production of the world during this year. 6000 w. Eng & Min Jour—Jan. 6, 1900. No. 31783.

Proof.

Proof Gold and Silver. Cabell Whitehead. Describes the method of preparing pure gold and silver in use at the mints. 1100 w. Eng & Min Jour—Dec. 30, 1899. No. 31665.

Valuation.

The Valuation of Gold Concessions in the Transvaal (L'Evaluation des Concessions Aurifères au Transvaal). G. Braecke. A description of the methods employed in sampling and assaying the deposits; also of estimating the working expenses, in order to arrive at the commercial value of a claim. 5000 w. Rev Univ des Mines—Dec., 1899. No. 32-128 G.

Washington.

Lake Chelau District. Arthur Lakes. An illustrated account of an undeveloped mining district in the State of Washington. 3000 w. Mines & Min—Jan., 1900. No. 31855 C.

IRON AND STEEL.

Blowing Engine.

See Mechanical Engineering, Special Motors.

Casting.

The Uehling Casting Machine (Die Uehlingsche Giessmaschine). Ed. A. Uehling. A paper read before the Eisenhütte Düsseldorf devoted mainly to a description of the operation of the Uehling casting machine at the Carnegie Works in Pennsylvania. 2000 w. Stahl und Eisen—Jan. 1, 1900. No. 32149 D.

Classification.

Metric Classification of German Iron Manufactures. A copy of the classification of German iron manufactures as given in the report of the British Consul. 700 w. U. S. Cons Repts, No. 635—Jan. 23, 1900. No. 32012 D.

Germany.

The German Iron Industry in the Year 1899. Emil Schroedter. Reports a very prosperous year for both iron and coal. 1900 w. Ir & Coal Trds Rev—Dec. 29, 1899. No. 31825 A.

The Iron and Steel Industries of Germany. R. M. Daelen. Shows the recent development of the iron industry, and the improvements in the works. 3800 1900 w. Ir & Coal Trds Rev—Dec. 29, 1899. No. 31824 A.

High Temperatures.

The Color Names for High Temperatures. Henry M. Howe. Compares results of Messrs. White and Taylor, and the writer with Pouillet's data concerning colors of heated steel, and advises the abandoning the latter. 1200 w. Eng & Min Jour—Jan. 20, 1900. No. 32009.

Iron.

Some Phenomena Presented by Iron (Sur quelques Phénomènes que présente le Fer). M. Galy-Aché. An examination of phenomena relating to allotropic forms of iron, including behaviour under high pressures and under rapid cooling. 1200 w. Comptes Rendus—Dec. 26, 1899. No. 32125 D.

Iron Ore.

Greatest Lake Iron Ore Output. Horace J. Stevens. Review of the tonnage during this and past years, giving estimates of future outputs. 3000 w. Am Mfr & Ir Wld—Jan. 4, 1900. No. 31754.

Iron Trade.

Our Review of the Iron and Steel Trades in 1899. A review of British imports and exports, and report dividends paid. 4400 w. Ir & Coal Trds Rev—Dec. 29, 1899. No. 31823 A.

The Chicago Iron Trade in 1899. Reviews the general features, and also the trade by months, giving tables of prices, and reporting a very encouraging outlook. 5000 w. Ir Age—Jan. 4, 1900. No. 31748.

The Philadelphia Iron Trade in 1899. Thomas Hobson. Review of the most eventful year ever experienced. 3000 w. Ir Age—Jan. 4, 1900. No. 31747.

The Pittsburg Iron Trade in 1899. Robert A. Walker. Report of the greatest year the iron trade has ever known, discussing details. 12500 w. Ir Age—Jan. 4, 1900. No. 31749.

Japan.

Japanese Steel Works, Yawatamura. An account of two blast furnaces being erected for the making of rails, rods, sheets, and cast-steel. 1200 w. Am Mfr & Ir Wld—Jan. 18, 1900. No. 31973.

The Recent Industrial Development of Japan (Die Neuere Industrielle Entwicklung Japans). Especially discussing the iron and steel industry, with plan and illustrations of the Imperial Japanese Steel Works at Yawatamura. 3000 w. Stahl und Eisen—Dec. 15, 1899. No. 32145 D.

Madagascar.

The Iron Industry of Madagascar (L'Industrie du Fer à Madagascar). A review of the tour of investigation recently made by M. Breton, showing the presence of workable deposits of iron ore in various parts of the island. 2000 w. Moniteur Industriel—Jan. 6, 1900. No. 32184 F.

Manufacture.

Iron and Steel Works Plant. Harry B. Toy. Read before the South Staffordshire Iron and Steel Inst. Describes an economical plant for producing about 1000 tons per month of iron bars, criticising in detail. 3800 w. Col Guard—Dec. 22, 1899. No. 31734 A.

Manufacture of Iron in the East. B. H. Thwaite. Reviews the history of this industry and discusses the advisability of increasing the production in colonies possessing the raw materials. Ill. 1800 w. Ind & East Engr—Dec., 1899. No. 31969 D.

The Manufacture of Iron and Steel in India. R. H. Mahon. Abstract of a report to the Indian Government, 1899. Information relating to the capability of India for steel manufacturing. Map. 5700 w. Col Guard—Jan. 19, 1900. Serial. 1st part. No. 32233 A.

Material Transport.

Economy in the Transport of Raw Materials in Iron Manufacture (Ersparnisse in der Bewegung der Rohstoffe für die Eisendarstellung). E. Schrödter. A paper before the December convention of the Verein Deutscher Eisenhüttenlente discussing railway tariffs, and transport facilities for iron ore, fuel, etc., also the use of mechanical conveyors, etc., also discussion. 8000 w. Stahl und Eisen—Jan. 1, 1900. No. 32148 D.

Merchant Bar.

The Continuous System as Applied to the Rolling of Merchant Steel. Illustrated description of the system and plant. 1500 w. Ir Age—Jan. 18, 1900. No. 31966.

Nickel-Steel.

Nickel-Steel; A Synopsis of Experiment and Opinion. David H. Browne. Discusses the physical qualities of nickel and nickel-steel and the various uses of the metal. Ill. 21500 w. Trans Am Inst of Min Engs—Sept., 1899. No. 31656 D.

Production.

Iron and Steel. Report of the year 1899, showing great prosperity and productiveness. 7500 w. Eng & Min Jour—Jan. 6, 1900. No. 31784.

Steel.

The Effect of Heat-Treatment Upon the Physical Properties and the Microstructure of Medium Carbon Steel. Robert Gorham Morse. Gives results of investigations to determine how the tensile strength, the elastic limit, and the size of the grain, of a pure medium-carbon steel are affected by heating to successive temperatures between 500° and 1300° C., with slow cooling therefrom. Ill. 2500 w. Trans Am Inst of Min Engs—Sept., 1899. No. 31650 D.

Superior.

Lake Superior Iron Mines in 1899. Review of the ore shipments, mining purchases, and other matters of interest. 2000 w. Eng & Min Jour—Jan. 13, 1900. No. 31894.

Utah.

Utah Mines in 1899. Notes on the mining conditions in the State. 1500 w. Eng & Min Jour—Jan. 13, 1900. No. 31898.

Wire.

Recent Progress in Wire Manufacture. Briefly reviews the history of wire-mak-

ing, and gives an illustrated description of the recent English plant of the Bedson Wire Works in Middlesbrough. 3000 w. Ir & Coal Trds Rev—Dec. 22, 1899. No. 31720 A.

Wire and Wire-Drawing. J. Dixon Brunton. Abstract of a paper read before the West of Scotland Ir. and Steel Inst. Some of the important uses of wire are given, and the operation of drawing described, and other processes in its manufacture. 2500 w. Ir & Coal Trds Rev—Jan. 19, 1900. No. 32220 A.

MINING.

Austria.

The Mining Products of Austria in 1898 (Die Bergwerks produktion Oesterreichs in Jahre, 1898). An abstract of the official report, giving tables of both raw and manufactured mineral products, both as to weight and market value. 1500 w. Glückauf—Dec. 15, 1899. No. 32156 B.

Accidents.

Fatal Accidents in Coal Mining in North America. Frederick L. Hoffman. Data for the year 1898 and explanatory information for the previous nine years. 1300 w. Eng & Min Jour—Jan. 27, 1900. No. 32095.

Belgium.

The Belgian Mining Industry for 1898 (Die Belgische Bergwerksindustrie im Jahre, 1898). A detailed abstract of the official report of the Belgian government, including coal, coke, metallic ores and operating statistics. 1800 w. Glückauf—Dec. 23, 1899. No. 32159 B.

Colorado.

San Miguel County, Colorado, Mines in 1899. Reviews the work of this district for the past year. 3000 w. Eng & Min Jour—Jan. 20, 1900. No. 32011.

Drilling.

Diamond Drilling Machines. H. M. Lane. Gives some of the peculiarities, advantages and disadvantages of the different types of machines in use, describing the feed arrangements, methods of uncovering the hole, hand drills and their capabilities, and a few facts as to costs. 4400 w. Mines & Min—Jan., 1900. No. 31848 C.

Electric Power.

The Application of Electric Power to Mining in British Columbia. George P. Low. A brief account of the Kootenay-Rossland transmission. 3400 w. Can Min Rev—Dec. 31, 1899. No. 31698 B.

Errors.

Mining Errors. F. Danvers Power. Read before the New South Wales Chamber of Commerce. Notes on a few of the principal errors that are found in the practice of mining, especially in prospecting, promoting and managing. 6700 w. Can Min Rev—Dec. 31, 1899. No. 31697 B.

Explosives.

A New "Permitted" Gunpowder. Donald M. D. Stuart. Some information concerning high-grade gunpowders, with illustrations of shots in blasting work. 1600 w. Col Guard—Jan. 19, 1900. No. 32234 A.

The Application of Explosives. Charles E. Munroe. Illustrates and describes some of the methods of producing explosives and also their applications. 2500 w. Ap Pop Sci M—Jan., 1900. Serial. 1st part. No. 31657 C.

The Use of Explosives in Belgian Collieries. Victor Watteyne. From a communication to the *Annales des Mines de Belgique*. Information concerning the quantities used, and the progress in safety. 2200 w. Col Guard—Jan. 5, 1900. No. 31930 A.

Firedamp.

The Ignition of Firedamp and Coal Dust by Means of Electricity. Sydney F. Walker. Gives a résumé of the contents of a paper by Bergassessor Heise and Dr. Theim recording experiments on this subject, and considers the results. 3000 w. Col Guard—Jan. 12, 1900. Serial. 1st part. No. 32037 A.

Haulage.

Slope No. 6, Pratt City, Alabama. Neill Hutchings. An example of endless rope haulage is described. 1300 w. Mines & Min—Jan., 1900. No. 31852 C.

Laccolites.

Laccolites and Their Relation to Ore Deposits. Illustrated description of interesting geological features, showing the difference between postular uplifts and true laccolites. 1700 w. Min & Sci Pr—Dec. 30, 1899. Serial. 1st part. No. 31695.

Machinery.

The Machinery in the Transvaal Gold Mines (Die Maschinen in den Goldgruben Transvaals). Kurt Schweder. An account of the engines, compressors, pumps and other machinery in the Transvaal mining country, showing the very high grade and modern character of the plants. 2500 w. Glückauf—Dec. 16, 1899. No. 32155 B.

Mexico.

Mexican Resources. J. W. Gray. An account of the country, its natural riches, and the opportunities they offer for profitable development. 1200 w. Mines & Min—Jan., 1900. No. 31854 C.

Mine Water.

See Mechanical Engineering, Hydraulics.

Mining Capital.

The Redemption of Capital Expenditure upon Collieries and the Valuation of Mining Capital, etc. George Johnson. Discusses the different ways and means which may be employed to attain this object. 2200 w. Col Guard—Jan. 12, 1900. No. 32038 A.

Mining Law.

The Calhoun-Ajax Case. The Rights of Tunnels and of Locations on Cross Veins. A recent decision of the Supreme Court of Colorado on a subject of importance. 4800 w. Eng & Min Jour—Dec. 30, 1899. No. 31663.

Mining Plant.

See Electrical Engineering, Power Applications.

Ores.

Notes on Ore Dressing. A. W. Warwick. Briefly notes the ancient systems, and the modern improvements, the course of treatment in a wet plant and a few principles governing the design of a perfect mill. 1700 w. Min & Sci Pr—Jan. 13, 1900. No. 31971.

Ropes.

The Use of Slow-Moving Belt Ropes in Shafts. Harry Rhodes. Part first considers the advantages of this form of power transmission, and some of the details in the installation of such a plant. Ill. 1700 w. Prac Engr—Jan. 19, 1900. Serial. 1st part. No. 32231 A.

Saxony.

The Mining Statistics of the Kingdom of Saxony for 1898 (Statistik des Bergbaues im Königreich Sachsen für das Jahr, 1898). A tabulated abstract from the official Government report. 800 w. Glückauf—Dec. 23, 1899. No. 32158 B.

Separation.

The Wet Separation of Ores and Minerals. Walter J. May. Discusses some points in the methods used. 1800 w. Prac Engr—Jan. 5, 1900. No. 31911 A.

Shaft Accidents.

Arrangements for Preventing Shaft Accidents. M. Thiriart, in *Annales des Mines de Belgique.* Description of arrangements applied, and discussion of objections. Ill. 1700 w. Col Guard—Jan. 19, 1900. No. 32232 A.

Shafts.

Boring a Pair of Winding Shafts at the Bois-du-Luc Collieries. A. Demeure. From a communication to the *Annales des Mines de Belgique.* Illustrated detailed description. 3300 w. Col Guard—Dec. 22, 1899. No. 31735 A.

Means for Preventing Shaft Accidents. Leon Thiriart. From a communication to the *Annales des Mines de Belgique.* Illustrated description of arrangements for enclosing cages during the travelling of workmen, and for weekly inspections, etc. 3000 w. Col Guard—Dec. 29, 1899. No. 31835 A.

Sinking Through Heavily Watered Strata. Richard Robinson. Read before the British Soc. of Min. Students. Directions, with illustrations. 1700 w. Ir & Coal Trds Rev—Jan. 19, 1900. No. 32218 A.

Stopes.

A New Method of Measuring Stopes. Fred T. Greene. Illustrated description. 600 w. Eng & Min Jour—Jan. 27, 1900. No. 32096.

Timbering.

A New Method of Coal Mining (Nouvelle Méthode d'Exploitation de la Houille). Describing method of timbering in the Grand Combe coal mines, by which the efficiency of operation is materially increased. 1200 w. Génie Civil—Dec. 16, 1899. No. 32101 D.

The Main Difficulty of the Timbering Problem. H. W. Halbaum. Examines a case of accident with the view of showing the difficulties to be overcome in the solution of timbering problems. Ill. 3500 w. Col Guard—Dec. 22, 1899. Serial. 1st part. No. 31732 A.

Ventilation.

Mine Ventilation. James Grant. Describes and discusses the three methods employed, and the difficulties. 3000 w. Aust Min Stand—Nov. 30, 1899. Serial. 1st part. No. 31710 B.

Sources of Error in the Proportioning of Mine Workings (Ueber die Fehlerquellen bei der Bestimmung der Grubenweiten). L. Volf. A detailed discussion of the method of computing the proper dimensions for passages in mines, with especial reference to the Murgue system of ventilation. 3000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Dec. 30, 1899. No. 32161 B.

Winding Engines.

Experiments with Compound Winding Engines. J. Divis. *Oesterreichische Zeitschrift für Berg und Hüttenwesen.* Report of tests made to gain information of the relative superiority of compound *versus* non-compound engines for winding in mines. 1000 w. Col Guard—Dec. 22, 1899. No. 31733 A.

MISCELLANY.

Aluminum.

See Electrical Engineering, Miscellany.

Kimberley.

The Diamond Mines of Kimberley. History of the discovery and working of

this great diamond field. Ill. 1400 w. Sci Am—Jan. 27, 1900. No. 32048.

Lead.

Lead in 1899. Report of the production in the United States and of the New York and London markets. 2200 w. Eng & Min Jour—Jan. 6, 1900. No. 31785.

Minerals.

The Metal and Mineral Output of the United States in 1899. A summary of the production of the more important metals and minerals. 3200 w. Eng & Min Jour—Jan. 6, 1900. No. 31781.

Ore Transportation.

Iron Ore—From Mine to Furnace. Waldon Fawcett. Illustrated description of transportation facilities from Lake Superior mines to the vicinity of Pittsburg. 1300 w. Eng & Min Jour—Jan. 20, 1900. Serial. 1st part. No. 32010.

Peat.

The Use of Peat as Fuel. Gives a brief account of efforts to turn bog lands to account, and the uses for which peat is adapted, and its proper preparation. 1400 w. Col Guard—Jan. 5, 1900. No. 31929 A.

Petroleum.

Petroleum in 1899. Reports an improvement in the production in the United States, and encouraging features of the industry. 1000 w. Eng & Min Jour—Jan. 6, 1900. No. 31789.

Quartz.

The O. P. Q. Quartz-Mine, Waipori, Otago. Describes the working and the working plant. 1700 w. N. Z. Mines Rec—Nov. 16, 1899. No. 31709 B.

Saltpetre.

The Occurrence and Manufacture of Chili Saltpetre. A lecture by Dr. Weitz, in Berlin. Illustrated description of the deposits and the production. 3000 w. Ir & Coal Trds Rev—Dec. 29, 1899. No. 31826 A.

Schist.

The Bituminous Schist Industry in France (L'Industrie des Schistes Bitumineux en France). A comparison of the French and Scotch industries, calling attention to the superior output of mineral oil, paraffine, etc., obtained by the Scotch process of distillation. 1800 w. Moniteur Industriel—Dec. 30, 1899. No. 32183 F.

Smelting.

Silver and Lead Losses in Lead Smelting. L. D. Godshall. Discusses statements made and conclusions drawn by Dr. Iles. 2400 w. Eng & Min Jour—Jan. 13, 1900. No. 31892.

Tin.

Lode Tin Mining in the Malay Peninsula. W. H. Derrick. Abstract of paper read before the Inst. of Min. and Met., Lond. Notes on vein mining, describing methods of mining and dressing the ore. 1700 w. Eng & Min Jour—Dec. 30, 1899. No. 31664.

Tin in 1899. Shows the tin received from foreign markets, and gives reports of the trade in New York and London. 3500 w. Eng & Min Jour—Jan. 6, 1900. No. 31786.

Unloader.

See Mechanical Engineering. Power and Transmission.

Zinc.

Zinc in 1899. Report of production and the markets. 4200 w. Eng & Min Jour—Jan. 6, 1900. No. 31787.

RAILWAY AFFAIRS

CONDUCTING TRANSPORTATION.

Employees.

Railroad Relief and Beneficiary Associations. W. H. Baldwin, Jr. Address before the Am. Econ. Assn., Ithaca, N. Y. Considers the development of these features of railroad organization, and their bearing upon the relations between corporations and their employees. 4000 w. Ry Age—Jan. 12, 1900. No. 31902.

Fast Run.

A Fast American Run. Hiram Percy Maxim. An account of a run from Atlantic City to Philadelphia on a Columbia electric automobile, which is supposed to be the fastest long-distance run made by an electric automobile. Ill. 1600 w. Auto Mag—Jan., 1900. No. 31689 C.

France.

A View of the Recent Improvements in Railway Service in France (Coup d'Oeil sur les Récentes Améliorations Réalisées par les Grandes Compagnies Françaises de Chemins de Fer). A. Mange. A discussion of the improvements in the interest of travelers which have been made in France during the past ten years, both as regards tariffs and improved accommodations. 6000 w. Rev Gen des Chemins de Fer—Jan., 1900. No. 32136 G.

The French Winter Train Service. Charles Rous-Marten. Gives a list of the chief expresses in France, with comments on the progress with respect to speed. 800 w. Engr, Lond—Dec. 22, 1899. No. 31729 A.

MOTIVE POWER AND EQUIPMENT.

Air Brakes.

Testing Cock for Air Brakes. J. P. Kelly. Illustrates and describes the writer's design. 900 w. Loc Engng—Jan., 1900. No. 31678 C.

The First Air Brake—A Short History; also Reminiscences of Its First Engineer. An interesting illustrated account of the first air-braked train. 2000 w. Loc Engng—Feb., 1900. No. 32243 C.

Bogie Wagons

Fifty-Ton Bogie Wagons for the Caledonian Railway. Illustrations showing details, also brief description. 500 w. Engng—Jan. 19, 1900. No. 32215 A.

Car Lighting.

A New System for the Electric Lighting of Railway Carriages (Ein Neues System der Elektrischen Beleuchtung von Eisenbahnwagen). H. Massenbach. A paper before the Frankfurt Electrotechnical Society discussing the Pollak system, which employs a generator driven by the car axle, a small storage battery, and an automatic switch. 3500 w. Elektrotech Zeitschr—Jan. 11, 1900. No. 32173 B.

Coal Cars.

36-Foot 80,000-Pound Coal Cars. S. S. Stiffey. Illustrates and describes cars weighing 29,000 pounds, built of wood and having the side boards outside of the stakes. 600 w. Am Engr & R R Jour—Jan., 1900. No. 31680 C.

Counterbalancing.

A New Method of Counterbalancing Locomotives. Describes a system invented by P. Z. Davis. Ill. 800 w. Ry Age—Jan. 26, 1900. No. 32236 D.

Electric Traction.

Electric Traction in Railway Work. Abstract of a paper read before the Glasgow and West of Scotland Technical College Scientific Society. Discusses the advisability of substituting electric traction on steam roads. 2700 w. Tram & Ry Wld—Jan. 11, 1900. No. 32068 A.

Freight Cars.

Character of Breakages Shown in Service of Modern Freight Cars. Editorial discussion of defects arising in operation, and the treatment these heavy cars receive. 1200 w. Ry & Engng Rev—Jan. 27, 1900. No. 32238.

Injectors.

A Little About Injectors. C. B. Conger. A plain talk for railway engineers and firemen about operation of these instruments. 2400 w. Loc Engng—Feb., 1900. No. 32239 C.

Locomotives.

American Locomotives in England 60 Years Ago. W. H. Lewis. A letter concerning the Norris engines on the Birmingham & Gloucester railway in 1840. 400 w. Loc Engng—Feb., 1900. No. 32242 C.

Brooks Eight-Wheel Passenger Locomotive—C. & A. Ry. Illustrated detailed description. 1500 w. Ry & Engng Rev—Jan. 20, 1900. No. 32045.

Compound Express Engine. Illustrates and describes a Northern Counties of Ireland express engine, giving the running time. 600 w. Engr, Lond—Jan. 5, 1900. No. 31920 A.

Exhaust and Draft in Locomotives. From the report of C. H. Quereau. Gives a summary of American practice, with discussion and conclusions. 4300 w. R R Gaz—Jan. 19, 1900. No. 31978.

French Fast-Passenger Locomotive. Illustrated detailed description of engine used on the Chemin de Fer du Nord. 600 w. Ry & Engng Rev—Dec. 30, 1899. No. 31693.

Narrow-Gauge Locomotive. Illustrated description of a narrow-gauge, side tank locomotive, one of six constructed for the Sierra Leone Ry. 800 w. Engr, Lond—Jan. 12, 1900. No. 32043 A.

Some Veteran Locomotives. Alfred R. Bennett. Illustrates and describes some engines built in 1846 and 1847 in daily work on the Main-Neckar Ry. of Germany. 500 w. Engng—Jan. 12, 1900. No. 32035 A.

Ten-Wheel Tandem Compound Passenger Locomotive of the Atchison, Topeka & Santa Fe Ry. Illustrated detailed description. 1100 w. R R Gaz—Jan. 12, 1900. No. 31873.

The New Compound Express Locomotive for the North-Eastern Railway of Switzerland (Die Neue Verbund-Schnellzugs-Lokomotive der Schweizerischen Nordostbahn). A general specification of this two-cylinder compound, with sectional view, and indicator diagrams taken at speeds from 36 to 48 miles per hour. 1800 w. 1 plate. Schweizerische Bauzeitung—Dec. 30, 1899. No. 32138 B.

Lubrication.

Packing and Lubrication. A copy of the general instructions recently put in force on the New York Central & Hudson Riv. R. R. 2800 w. R R Gaz—Jan. 26, 1900. No. 32082.

Metal Cars.

The Goodwin Steel Car in Collision. John M. Goodwin. Illustrated description, showing recent progress in metal car construction. 900 w. R R Gaz—Jan. 12, 1900. No. 31875.

St. Gothard.

The New Equipment of the St. Gothard Railway (Le Matériel Nouveau du Chemin de Fer du Gothard). M. Lancrenon.

A very full account of the heavy new engines and carriages for the St. Gothard railway, with numerous illustrations and a diagram showing the increased traffic. 3000 w. 3 plates. Rev Gen des Chemins de Fer—Dec., 1899. No. 32133 G.

Siege Train.

Siege Train for the War. Illustrates the trucks and locomotives forming the train supplied to the British war office, giving an account of the rapid work in connection with the order. 1300 w. Engr, Lond—Jan. 19, 1900. No. 32211 A.

Staybolts.

Flexible Staybolts. F. W. Johnstone. Illustrates and describes these staybolts as applied on the locomotives of the Mexican Central railroad. 2300 w. Am Engr & R R Jour—Jan., 1900. No. 31679 C.

Steel Cars.

The Development of the Steel Car. Notes on the large number of cars in service and in demand, giving some of the troublesome features. 1500 w. Am Engr & R R Jour—Jan., 1900. No. 31-681 C.

Transfer Table.

The Electric Transfer Table of the Orleans Railway (Le Chariot Transbordeur Electrique de la Compagnie d'Orleans). M. Sabouret. Describing an improved electric transfer table, requiring no pit to be excavated; the whole structure being above the main track level. 2500 w. 1 plate. Rev Gen des Chemins de Fer—Dec., 1899. No. 32134 G.

PERMANENT WAY AND FIXTURES.

Boston.

The South Terminal Station, Boston, Mass. George B. Francis. An illustrated detailed description of the engineering features. 17500 w. Pro Am Soc of Civ Engs—Dec., 1899. No. 31-703 E.

Coaling Station.

The 600-Ton Coaling Station of the Lehigh Valley Railroad. An illustrated detailed description of a recently completed station at South Plainfield, N. J. 1200 w. R R Gaz—Jan. 5, 1900. No. 31758.

Crossings.

Grade Crossings. Augustus Mordecai. Brief discussion of the rights of parties interested and the justice each should be awarded. 2700 w. Jour Assn of Engng Socs—Dec., 1899. No. 32019 C.

English Railways.

The Early Railways in Surrey. Gives the history of the Surrey Iron Railway, the first one sanctioned by Parliament, and its failure, in the present article. 3800 w. Engr, Lond—Jan. 5, 1900. Serial. 1st part. No. 31919 A.

Grades.

Momentum Grades. C. Frank Allen. Explains the principle involved in the use of these grades, and discusses the objections to their indiscriminate use. 2400 w. R R Gaz—Jan. 12, 1900. No. 31872.

Theory of Velocity Grades. Two letters to the editor criticising Mr. Wentworth's explanation, and his tractive force formula. 2000 w. R R Gaz—Jan. 26, 1900. No. 32080.

Manchester.

The Great Northern Railway in Manchester. Illustrated description of the new Deansgate station and warehouse. 1700 w. Transport—Jan. 19, 1900. No. 32244 A.

Review.

A Half Century of Railway Building. Gives a comparison by decades, with diagrams. 600 w. Ry Age—Jan. 12, 1900. No. 31901.

Siberian.

My Journey on the Siberian Railway (Meine Fahrt auf den Sibirischen Eisenbahnen). Nicholaus Post. An engineer's account of observations on the Trans-Siberian Railway, with maps and views of bridges and road construction. Serial. Part I. 3500 w. Zeitschr d Oesterr Ing u Arch Ver—Jan. 5, 1900. No. 32116 B.

The Siberian Railroad. Remarks from Russian papers criticising some points in the construction, etc. 1600 w. U. S. Cons Repts, No. 626—Jan. 12, 1900. No. 31867 D.

Signalling.

American Practice in Block Signalling. B. B. Adams. The first of a series of articles giving a thorough revision of matter published eight years ago, and aiming to treat the subject from a practical standpoint. Ill. 2000 w. R R Gaz—Jan. 5, 1899. Serial. 1st part. No. 31-759.

Automatic Block Signalling. Edward C. Carter. Compares the semaphore and disc signals, stating the objections to each and discussing their operation and maintenance, installation, etc. 3500 w. R R Gaz—Jan. 12, 1900. No. 31874.

Automatic Interlocking at Hawley, Illinois. Illustrated description. The features of interest are the use of automatic brake-setting devices, and the use of "power-storing" machines for throwing all of the signals. 3000 w. Ry & Engng Rev—Jan. 6, 1900. No. 31778.

Railway Signalling in America. Reviews recent papers by H. M. Sperry, A. J. Wilson, and Frank Rhea. 2200 w. Engr, Lond—Dec. 29, 1899. No. 31828 A.

Signalling as It Is and as It Might Be. A. H. Rudd. Part first gives a review of the progress of signalling. 1700 w. R R

Gaz—Jan. 26, 1900. Serial. 1st part. No. 32081.

Supplements to Railway Signalling (Brierley's Apparatus). An illustrated description of an arrangement for giving indications on the engine itself, to avoid danger in fogs. 2000 w. Elec Rev, Lond—Dec. 29, 1899. No. 31816 A.

Terminal Improvements.

Great Northern Terminal Improvements at Seattle, Wash. Plans and description of a proposed union passenger station, yard tracks, etc. If not approved as a union station, with slight changes the plans will be carried out as a station for the road named. 1200 w. Ry & Engng Rev—Jan. 27, 1900. No. 32237.

Ties.

The Artificial Preservation of Railroad Ties by the Use of Zinc Chloride. Continued discussion of paper by Walter W. Curtis. 3300 w. Pro Am Soc of Civ Engs—Dec., 1899. No. 31706 E.

Track Elevation.

Track Elevation in Chicago. Commences an illustrated description of the extent and character of the work done by each railway company. Also editorial. 7500 w. Eng News—Jan. 11, 1900. No. 31864.

Ventilation.

The Ventilation of the St. Gotthard Tunnel (La Ventilation du Tunnel du Saint-Gothard). A detailed description of the Saccardo system as installed at Goeschenen for the maintenance of a constant current of air through the tunnel; with graphical diagrams showing the velocity of the air. 5000 w. 1 plate. Rev Gen des Chemins de Fer—Nov., 1899. No. 32132 G.

STREET AND ELECTRIC TRAMWAYS

Aberdeen.

The Aberdeen Corporation Electric Tramways. Illustrated detailed description. 1400 w. Tram & Ry Wld—Jan. 11, 1900. No. 32066 A.

Berlin.

Tramway Projects in Berlin. D. B. Macgowan, in the *Chicago Tribune*. An account of the lines under construction and in operation. 1900 w. Tram & Ry Wld—Jan. 11, 1900. No. 32067 A.

Brooklyn.

The Traffic Difficulties of the Brooklyn Rapid Transit System. An illustrated discussion, with maps, showing the difficulties and transportation trials, and considering the only remedy to be the increasing the dry land communication between Manhattan and Brooklyn. 2200 w. St. Ry Jour—Jan. 6, 1900. No. 31801 D.

Changing Power.

Opening of the Third Avenue Railway, N. Y. Illustrated account of the changing of the main lines of this railway from cable to electricity, using the underground conduit system. 3600 w. St Ry Jour—Jan. 6, 1900. No. 31800 D.

Como.

The Electric Tramway at Como (Die Elektrische Strassenbahn in Como). R. v. Podoski. Giving details of the wiring of the motor cars and the construction of the trucks. Also diagrams showing the operation of the brakes on steep inclines. 3000 w. Elektrotech Zeitschr—Jan. 4, 1900. No. 32167 B.

Controller.

Saving at the Controller. J. R. Cravath. Considers how current is usually wasted in operating cars and gives suggestions concerning instructions that should be given motormen. 2200 w. St Ry Rev—Jan. 15, 1900. No. 31999 C.

Development.

Electric-Railway Development of 1899. James R. Chapman. Review of progress and the tendencies in construction and equipment. 1200 w. W Elect'n—Jan. 6, 1900. No. 31805.

Efficiency.

The Relation between Receipts and Car Efficiency in Street Tramways (Beziehungen Zwischen Einnahmen und Wagen-Kilometerleistung bei Strassenbahnbetrieb). W. Mattersdorff. Giving a number of diagrams plotted from German tramways, showing the commerical advantages of high car-mile efficiency. 2000 w. Elektrotech Zeitschr—Dec. 21, 1899. No. 32164 B.

Electric Locomotives.

Some Recent Electric Freight Locomotives. Burcham Harding. Describes and illustrates a novel type for hauling freight cars over electric lines. 600 w. Eng. News—Jan. 25, 1900. No. 32075.

Electric Railway.

The Detroit, Ypsilanti & Ann Arbor Electric Railway. Illustrates and describes this example of modern practice in the equipment of an interurban traction system. 3500 w. St Ry Rev—Jan. 15, 1900. No. 31997 C.

Electrolysis.

The Prevention of Electrolysis. Alton D. Adams. Discusses the damage

from currents of electric railways, the conditions that produce ground currents and the remedy. 3000 w. Munic Engng —Jan., 1900. No. 31699 C.

Energy Distribution.

Distribution of the Energy of a Pound of Coal in the Electric Railway Cycle. Albert B. Herrick. Diagram showing in a graphic way the magnitude and location of the various losses in street railway operation. 1500 w. St Ry Jour—Jan. 6, 1900. No. 31799 D.

Feeders.

Aluminum Feeders on the Northwestern Elevated Railroad, Chicago. Illustrated description of the installation and the methods used in handling the wire and manner of overcoming difficulties. 2000 w. Am Elect'n—Jan., 1900. No. 31797.

Gas Traction.

Gas Traction on Tramways at Blackpool. Lytham and St. Annes. W. Chew. Read before the Manchester Dist. Inst. of Gas Engs. Information concerning this line successfully worked by gas. 1500 w. Gas Engs' Mag—Jan. 10, 1900. No. 32-223 A.

Italy.

Electric Traction on the Secondary Railways of Italy (Essais de Traction Electrique sur les Lignes de Chemins de Fer Secondaires en Italie). R. Godfernaux. Describing the various lines now in successful operation in Italy, with data concerning costs and returns of operation. 5000 w. 1 plate. Rev Gen des Chemins de Fer—Dec., 1899. No. 32135 G.

Milwaukee.

Milwaukee Electric Tramways. An Illustrated description of the installation. 2500 w. Tram & Ry Wld—Jan. 11, 1900. No. 32065 A.

Omnibus.

See Mechanical Engineering, Automobilism.

Paris.

Electric Traction in Paris. Illustrates and describes the novel features in construction. 1800 w. Elect'n, Lond—Jan. 12, 1900. No. 32025 A.

Public Transportation Facilities in Paris and its Vicinity (Les Transports en Commun dans Paris et sa Banlieue). Charles Jean. A review of the present and proposed facilities, including omnibuses, horse, steam, and cable tramways, and steam railways, in view for the heavy demands upon the service expected during the Exposition. Serial. Part I. 3500 w. Génie Civil—Jan. 13, 1900. No. 32108 D.

Power Stations.

New Main Power Station of the Third Avenue Railroad Company, New York. Illustrated detailed description of the structure, which will be the largest station in the world, and the main features of the steam plant. 9000 w. St Ry Jour —Jan. 6, 1900. No. 31798 D.

The New Power Station of the Third Avenue Railroad Company. Illustrated description of a 72-000-H. P. station in New York, used for distributing 3-phase current from railway service. 2200 w. Eng Rec—Jan. 6, 1900. No. 31767.

The New Street Railroad Power Stations in New York City. Brief illustrated descriptions of the stations of the Metropolitan Co., and the Third Ave. R. R. Co. 1200 w. R R Gaz—Jan. 12, 1900. No. 31876.

Rail Wagon.

The Bonner Rail Wagon. Illustrated description of an invention for cheapening transportation and the handling of freight in connection with electric trolley roads. 700 w. Sci Am—Jan. 13, 1900. No. 31845.

Statistics.

The Statistics of the Electric Railways of Germany (Statistik der Elektrischen Bahnen in Deutschland). The annual tabulated statement, giving data for existing and proposed roads, and a general summary down to September 1, 1899. 10000 w. Elektrotech Zeitschr—Jan. 4, 1900. No. 32170 B.

Suspended Road.

The Suspended Railway between Barmen, Elberfeld, and Vohwinkel (Die Schwebebahn Barmen-Elberfeld-Vohwinkel). Illustrated account of the curious railway connecting Barmen and Elberfeld, with their suburbs. The cars are hung from single overhead rails, and propelled by electricity. 1200 w. Deutsche Bauzeitung—Dec. 23, 1899. No. 32-182 B.

Switzerland.

The Full-Gauge Electric Railway between Burgdorf and Thun (Die Elektrische Vollbahn Burgdorf-Thun). E. Thomann. With map and profile of the route, and views of the motor and trailer cars. The three-phase current is used. Serial. Part 1. 1200 w. Schweizerische Bauzeitung—Jan. 6, 1900. No. 32139 B.

Tracks.

Track Construction for Electric Railways. F. A. Vaughn. Illustrated discussion of important points in construction and maintenance, with description of present practice for urban and interurban lines. 3500 w. Wis Engr—Jan., 1900. No. 32014 D.

Track Construction in Buffalo. Illustrates and describes the trench construction, and smooth excavation construction, and the organization of the laborers. 800 w. St Ry Rev—Jan. 15, 1900. No. 32-000 C.

IMPROVED MACHINERY

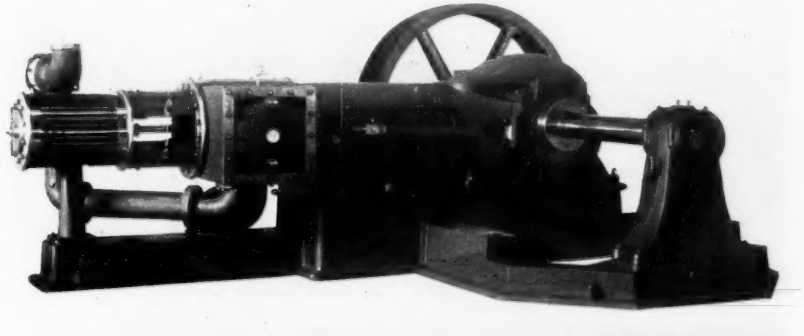
New Processes and New Appliances

The matter here published is not paid for, nor can it be classed as advertising. But as the information is necessarily obtained from those who offer the appliances for sale, it is proper to say that the manufacturers, rather than ourselves, are responsible for the statements made.

The Latest Ball Engine.

THE accompanying cut illustrates the latest addition to the line of engines built by the Ball Engine Co., of Erie, Pa. It represents an enclosed self-oiling engine, which comes the nearest to being wholly automatic of anything yet placed on the market.

In general appearance this engine is a new departure. Larger proportion and increased strength have been combined with graceful outlines. The same governor and



cylinder parts furnished with the standard engine are used in the new type, but many novel and valuable features have been added in the design of the other members. A large pocket in the crank end of the frame is filled with oil to such a level that the shaft discs just touch the surface. While the engine is at rest the whole system of oiling is inoperative, but with the first turns of the fly-wheels a stream of oil is thrown over the guides and connecting rod boxes and continues as long as the engine is in motion. A trough around the upper portion of the crank chamber catches a supply of oil and passes it to the main journals, which receive copious lubrication. These bearings are so constructed that, while not a drop of oil reaches the outside of the engine, the engineer may at any time watch the flow of oil or feel the journals. The guides are of the bored-out type, and by means of a special construction of the bed, the crosshead constantly floats in oil. This feature, together with the large bearing surfaces, practically eliminates wear in these parts.

Doors are provided on each side of the frame, and in the crank end there is a hand-hole plate for easy access to the working parts. In addition to these openings the removal of the corrugated hood on top lays the shaft and connecting rod bare for inspection or adjustment. Across the interior of the engine, between the discs and the guides, are two vertical plates, so placed as to allow the connecting rod to work freely between them. By their construction and position they direct the oil in a straight line to the crosshead and work a two-fold benefit; they limit the amount of oil thrown

to the guides to just enough for proper lubrication, and they allow the engine to be run with the side doors removed without the slightest danger of a drop of oil reaching the engine room floor. This will be found of great value when taking indicator cards or when watching the internal working of the engine.

The Ball Engine Co. have solved the problem of ventilation by providing a chamber in the cylinder end of the frame which prevents the oil from coming in contact with the heated surfaces of the cylinder head. Openings on each side allow the air to circulate freely and leave the piston stuffing box in full view. This chamber also forms a receptacle for the hot water of condensation from the piston stuffing box. Ample means of adjustment are provided wherever there is any liability of wear. The connecting rod is of the standard type, with strap keyed to the body, and wedges are provided at each end. As the wedges both move in the same direction, the length of the rod is not disturbed. The main shaft bearings are placed within the frame and have top and side adjustment. The crank shaft is a one-piece forging of the best open-hearth steel. The crank-pin is turned out of the solid and all bearings are ground perfectly round and true. Cast iron discs of the proper weight are securely fastened to the bells and keep the reciprocating parts in perfect balance. The cylinders are made of a special mixture of close-grained charcoal iron, and by reason of the hardness of the metal the bore soon becomes glazed and the wear inappreciable. All cylinder heads have steam tight ground joints to the cylinders. The construction of the head which connects the two cylinders is worthy of especial notice. The conical shells with tongue projections fit into grooves in the high and low pressure heads. Bolts passing through the tongues and grooves give to the whole the strength and rigidity of a single casting. This construction not only takes all shearing stress from the bolts, but allows the rapid dismembering of the head for examination of either cylinder, with the assurance that when re-assembled every part will take its original position.

The greatest factor to be considered when determining the economical qualities of an engine, is the valve, which takes care of the steam admission and exhaust. It is called upon to account for the proper distribution of every ounce of energy delivered to it. In some cases it resembles the proverbial new broom and works well only when new. The telescopic valve of the Ball engine is so constructed that it follows up its own wear and remains steam tight throughout its whole life.

Engines for electrical purposes have been the specialty of the Ball Engine Co. for over sixteen years, and direct-connected outfits form a large percentage of their output. The engravings shows the base and shaft extended, together with an outboard bearing ready to receive a dynamo. A fuller description of this engine can be obtained by addressing the manufacturers at Erie, Pa.

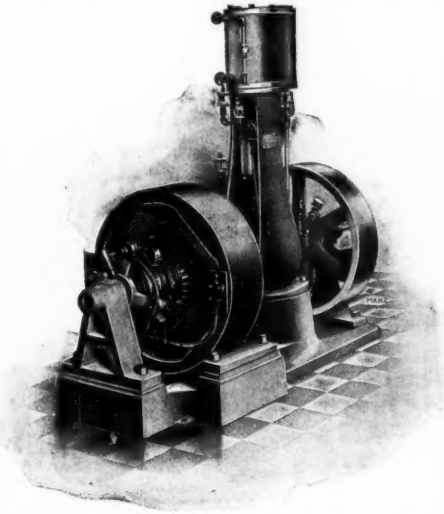
Electric Fan With Eight-Pole Motor.

In the accompanying illustration is presented a new type of motor-driven fan, which has been brought out by the B. F. Sturtevant Co., Boston, and which combines the features of compactness and lightness. The eight-pole feature naturally results in a lighter machine for a given output than is possible with a less number of poles.

For driving fans of this description it is necessary that the motor should be constructed for moderate speed, although in other classes of fan work extremely high speeds are desirable. The fan itself is of the "Monogram" type, built by this com-

pany. The shell is of cast-iron, the two sides being bolted together at the rim, and a separate outlet casing being attached.

The inlet is upon the side furthest from the motor, the motor side of the fan being closed, thereby preventing the drawing of dust across the commutator and armature.



The field ring, which combines the frame of the machine, is made of wrought iron, cast iron, or cast steel, according to the size, the sizes ranging from 3 to 137.5 horse-power motors.

Wrought-iron field cores are used, and a special type of cast-iron pole-shoe, which by its peculiar shape and size is one of the principal elements in rendering this machine capable of extreme variation of load without sparking of the brushes, or any shifting of adjustment whatever. The field coils are machine wound, and this form of field being extremely open, the windings present the greatest amount of radiating surface with consequent perfect ventilation, which prevents any great accumulation of heat. As these motors are designed with special reference to low speed and high efficiency, great care has been taken in determining the size of the armature that would be favorable to high efficiency at partial loads, and at the same time allow room for the necessary amount of copper. The armature coils are built up of laminated, slotted discs, mounted upon a cast-iron spider having a hub projection for the reception of the commutator. The core discs are solidly clamped between two brass rings, which have teeth to correspond with the core teeth, and which support them at both edges of the core, and not only protect the teeth from being damaged or misplaced, but present a smooth and well rounded corner for the support of the slot insulation. These armatures are of the coil wound drum type, and usually have the two-circuit winding, although in some cases a multiple winding is used. In the two-circuit winding there is opportunity for employing larger wire and fewer turns, thereby making the coil simpler and cheaper, while at the same time each coil has only only a fractional influence on the total electric force generated, so that the electrical balance of the armature is readily maintained. The special feature of this type of winding lies in the fact that as few as two sets of brushes can be used.

The commutator is of large diameter, with pure rolled or drop forged copper segments, supported in a cast-iron wheel of spider construction, thoroughly insulated with mica and micanite. Owing to the design, but little energy is dissipated at the brushes, and overheating of the commutator is not likely to occur. Reaction brushes of carbon are generally used, and supported on a special rigging which in turn is carried by brackets attached to the field ring. The tripod bearing-yokes serve to support the shaft upon each side of the machine and to render it independent. The bearings are provided with sleeves, which in the larger sizes are self-aligning, and ring oilers are used to secure positive and continuous lubrication.

A Direct-Connected Lighting Outfit.

THE direct-connected unit illustrated herewith is typical of a line of small electric lighting plants manufactured by the Commercial Electric Co., Indianapolis, Ind. They are especially desirable when the con-

ditions require a high-efficiency plant capable of being operated for long periods with little attention.

The engine is provided with the improved Rites governor, giving the closest regulation possible and has an efficient system of sight feed lubrication.

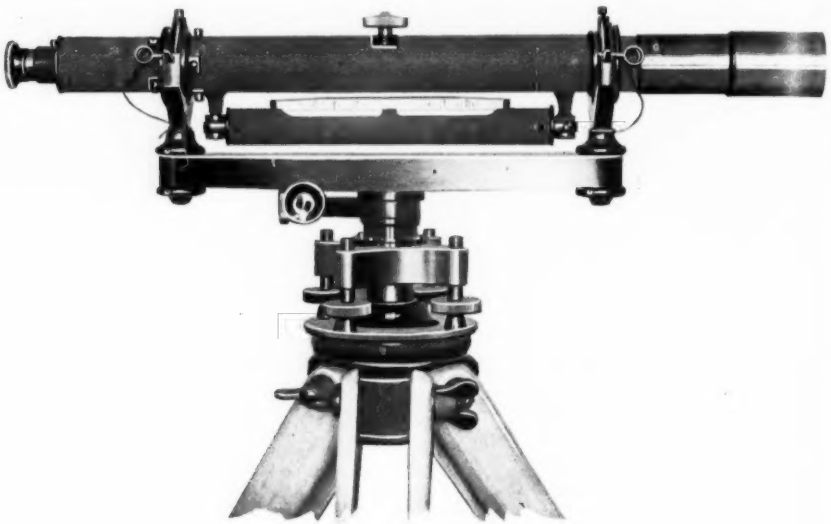
In the dynamo construction the conditions conducive to high efficiency of operation have been carefully studied, and in the design finally adopted it is believed the highest point of economy obtainable by the use of the best material and exact proportions has been secured. In the selection of the material for the dynamo frame, the universally recognized magnetic superiority of soft steel over cast-iron has determined its use for every part of the magnetic structure.

The armature is of the iron-clad type, with machine wound coils, each of which is separately insulated and tested, insuring perfect insulation of the complete armature. The great strength of the steel field-magnets and the use of a commutator with a large number of segments makes the regulation of the machine unusually perfect, and results in entire freedom from sparking under all loads. These plants are built in sizes from thirty lights upwards.

Recent Improvements in Wye Levels.

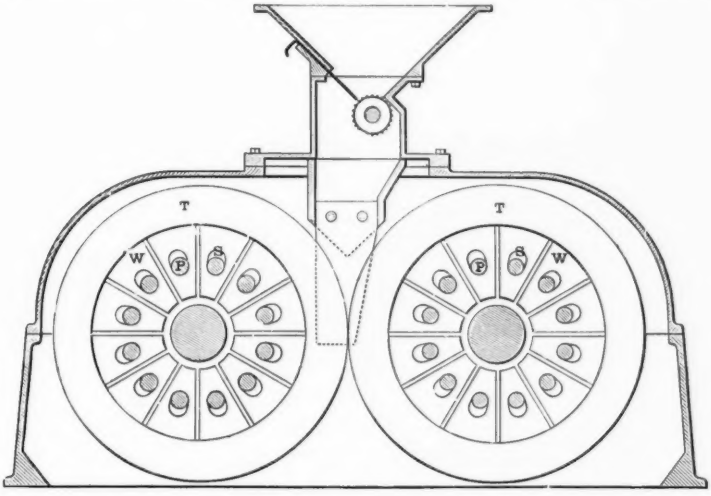
With the increasing demands for accuracy and precision on part of users of engineering instruments, the various makers of such instruments have constantly exerted themselves to meet the requirements so far as skill and materials will permit.

One of the difficult features in connection with the construction with the engineer's wye level has always been the center and socket forming the vertical axis upon which the instrument revolves. The usual practice is to use a hardened steel center in a socket of bell metal or phosphor-bronze,



but the different coefficients of expansion of the two metals have caused the effect of varying temperatures to be objectionable. In large astronomical instruments this difficulty is largely avoided by the use of hardened steel centers in sockets of annealed iron, but this construction has hitherto been withheld from engineer's levels by reason of the great expense incident to the setting up of precision grinding machines necessary to fit the hardened steel center, and also because of the rapid dulling of the reamers by the iron socket. A very important feature of this construction also lies in the use of a very high grade of charcoal iron for the socket.

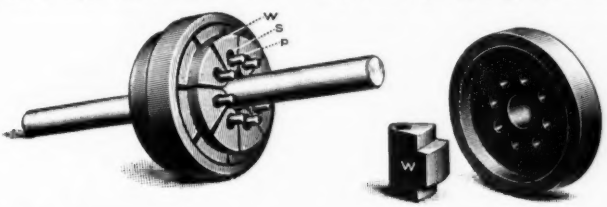
The Buff & Buff Mfg. Co., of Boston, Mass., whose 18 inch wye level is shown in the illustration, has successfully overcome these difficulties, and is now making levels with hardened steel centers and annealed iron sockets as a regular article of trade, the first six instruments of this type having been made in September, 1899, and these having attained great success in practical service. The great advantages of this construction lie not only in the small coefficient of expansion, but also in the fact that the expansion of the two metals is very nearly the same; besides which the coefficient of friction is low. In this way the form of center and socket which has found universal acceptance for astronomical instruments of the highest grade has now been commercially made possible for engineer's field instruments in all cases where there is no compass present to be affected by the magnetic properties of the iron.



The level shown in the illustration is provided with an 18 inch telescope of 1⅜ inch aperture and a power of 36 diameters, and contains, besides the steel centers and iron socket, all the highest refinements of construction involved in the execution of precision leveling of the most accurate character, and in its present form it represents the latest contribution to the equipment of the engineer made by the old and well-known house by whom it is made.

Centrifugal Crushing Rolls.

CENTRIFUGAL rolls are so named because they crush by utilizing the immense centrifugal forces generated by their rotations. No springs are needed to force the roll faces together, and although the space between the tire faces opens and closes, as in common rolls, yet, in centrifugal rolls neither shaft or roll or bearing has any backward or forward movement. For these reasons no crushing push can be transmitted to the roll shafts. These entirely



escape the direct shocks and the pounding caused by the backward and forward movements of the heavy common roll and its bearings.

Centrifugal rolls have also the singular property of automatically balancing themselves. Therefore, they run with nearly the steadiness of dynamos. Since the output of common rolls is directly as their peripheral velocities. centrifugal rolls, which easily run three times as fast as other rolls of equal size, should have three times their capacity, and, as a mater of fact, their output exceeds such estimates.

The centrifugal roll consists of but three important parts, namely, the shaft, the segment weights (W in the accompanying engravings), and the tire. The segment weights together, in operation, form a roll over which is placed the tire. Each weight is held to the shaft flanges by the pin, P, passing through the weight slot, S. Each weight rotating with the shaft, is set out by centrifugal force, and together the weights form, as before stated, a strong roll. The segment weights are prevented from giving expanding pressures to the tire by strong steel hub flanges. The slots, S, permit each weight to move back on its pin toward the shaft, but its backward movement can transmit no push to the shaft.

It is plain that the weights, W, in running hold the tire in position by the power of centrifugal force.

The tires in a pair of rolls can only be pushed back toward their shafts by a superior force, and as no rock is strong enough to exert such force it is easily crushed. If a bit of uncrushable steel gets between the rolls, and forces back the tires and weights, no harm is done, for no crushing shocks are transmitted directly to either shaft. The roll shafts are not pressed back at all. Centrifugal rolls, balancing themselves, run easily at all speeds. In the large sizes very moderate speeds give to centrifugal rolls ample crushing power. All rolls benefit by high peripheral speeds; but, while common rolls cannot run fast, centrifugal rolls can, and thus they have great effectiveness without large diameters.

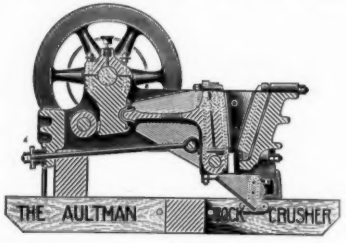
Centrifugal rolls run easily with small driving pulleys, and they require so much less power than slow running common rolls that no balance wheels are needed.

A fully illustrated descriptive circular will be sent free by the Sturtevant Mill Co., Boston, upon application.

The Aultman Rock Crusher.

THE rock crusher made by the Aultman Company, of Canton, Ohio, is an interesting machine to both the mechanic and the user of such machines. The inventor, Mr. Martin Hogan, member A. S. M. E., has designed and constructed an efficient, simple and very durable crusher of great capacity. The outward appearance of the crusher is very good, and the workmanship is excellent. The oiling facilities are ample and arranged to facilitate oiling while the crusher is in motion, without danger to the operator.

The construction within the housing is shown by the sectional view. A few strong, well-proportioned members, actuated by a cam shaft, produce a peculiarly efficient



crushing movement. The movement of the crushing jaw is peculiar. It is not only thrust forward and backward by the action of the cam shaft, but being supported by the swinging arm, some portion or another of the jaw is moving forward and crushing, practically throughout the entire revolution, but absolutely without a dead center. The machine is, therefore, always doing work, instead of half the time, as in machines in which the jaw swings from a pivotal point, whether top, bottom or middle.

The crushing movement is so perfect and continuous that the material works down and out without stopping. The crushing movement is always at right angles to the stationary jaw, thereby feeding the material downward. These elements of the machine largely account for its large capacity and excellent quality of product.

The crusher is also economical in the use of power, as shown by the results of re-

peated tests. Each crusher is tested at the works, and the average of all tests establishes that the power required is less than one horse power for one ton of capacity per hour, on material of average weight and hardness, reduced to pass two and a half inch ring.

The size of the product is regulated by take-up plates between the stationary jaw and housing. A change can be made in a few moments.

As will be noticed from the engraving, the wearing surfaces of pitman and toggle are bushed with renewable chrome steel plates. The jaws, when worn at lower end, can readily be inverted. In fact, all the minor details are worked out with the most careful and competent attention.

The policy of the company has been to go slowly in the introduction of this machine, until absolutely satisfied as to its merits. Some three hundred have been sold, and are in highly satisfactory use. The Aultman Company is now prepared to meet the full requirements of both domestic and export trade, and will cheerfully mail their catalogue to engineers or prospective purchasers in any part of the world.

New Pneumatic Hammer.

THIS new pneumatic hammer was recently brought out by the Philadelphia Pneumatic Tool Co., Philadelphia, Pa., and presents many improvements in point of design over other hammers now on the market. The most important detail of a hammer of this kind is, of course, the valve which controls the distribution of air to both ends of the tool and its final exhaust. The valve in this hammer moves longitudinally with the hammer barrel, but unlike other valves, moves in the same direction as the hammer piston at the same time, instead of in the opposite direction, as is usually the case. On account of this feature the impact of the blow, instead of having a tendency to jar the valve off its seat, causes it to be more firmly seated. A result of this construction is that the tool will continue to work efficiently even after the valve becomes considerably loosened by years of wear, and hence it is not necessary to be constantly repairing or renewing this vital part of the hammer. This motion of the value in unison with the piston also renders the action of the hammer more rapid, and hence more effective.

The hammer is provided with a self-closing, dust-proof oil-hole, so that oil can be gotten into exactly the right place, a regulator for conveniently controlling the supply of air through the throttle, and a lock to prevent looseness between the hammer and the handle.

Fuller descriptive details will be sent by the manufacturers on request.

Industrial Notes.

The town of Gastonia, N. C., has placed a contract with the New York Filter Manufacturing Co., of New York, for one of their filter plants to purify the water supply of the town. This company has also recently received contracts for water purifying plants from the following towns: Danville, Pa.; Canton, Pa.; Rocky Mount, N. C.; Norfolk, Va. The last is for a plant of two million gallons daily capacity to supplement one of six million gallons recently installed by the same company.

The Cincinnati Corrugating Co., Piqua, O., have just issued a new and handsome map of the South African Republic, Orange Free State and Cape Colony, the seat of the present warfare between England and the Boers. The map is excellently printed

in colors, and complete in details, thoroughly revised and up-to-date, showing all the points of interest in the war. The company will be pleased to mail a copy ready for hanging to anyone requesting same.

The Berlin Iron Bridge Co., of East Berlin, Conn., are putting up two large buildings for the National Coal Car Co., at Everett, Mass.; a gas plant for the Peekskill Gas Co., at Peekskill, N. Y.; a retort house for the Penn Yan Gas Light Co., at Penn Yan, N. Y.; a large car barn and power house for the Electric Railroad, at Montville, Conn.; the iron roofs for the new plant of the Nichols Chemical Co., at New York; two large buildings for the J. H. Horn & Sons Co., at South Lawrence, Mass.; a machine shop for the Wheeler & Wilson Mfg. Co., at Bridgeport, Conn.; a new power station at Tariffville, Conn.; a new machine shop for the Norwalk Iron Works, at South Norwalk, Conn.; a large steel building covering Pier 13, at New York; a power house for the Middletown Gas & Electric Co., at Middletown, N. Y., besides a large number of smaller contracts. They are running their plant full time, and report business exceedingly brisk.

At the annual meeting of the stockholders of the Berlin Iron Bridge Co., held at the office of the company in East Berlin, Conn., January 29, the capital stock was increased to $750,000. The following board of directors was elected: Chas. M. Jarvis, Frank L. Wilcox, S. H. Wilcox, H. H. Peck, Geo. H. Sage, D. E. Bradley and Seymour N. Robinson.

The new addition to the works of the B. F. Sturtevant Co., Boston, Mass., which was designed to meet the requirements of its rapidly growing electrical department, is already overcrowded, although completed only a few months ago. Numerous special orders for electric fans and generating sets for the Navy Department are being filled, and the construction of a complete line of enclosed motors of new design is now under way.

A second edition of the lecture by Walter B. Snow on "The Influence of Mechanical Draft Upon the Ultimate Efficiency of Steam Boilers," has just been issued by the B. F. Sturtevant Co., of Boston, Mass., by whom copies will be sent upon application.

One of the features of the new power plant of the Independent Electric Light & Power Co., of San Francisco, is a complete mechanical draft equipment, consisting of four fans arranged to operate upon the induced principle. These fans are arranged in pairs, each fan being 10 feet in diameter, and provided with an independent 8 x 12 horizontal engine, direct connected. This apparatus is being furnished by the B. F. Sturtevant Co., of Boston, Mass.

A large order has just been received by the Sprague Electric Company, of New York, for sixteen motors to be used in running the presses and machinery in a lithographing establishment in Tokio, Japan. It will be one of the finest equipped plants in Japan, and will be operated under the supervision of a Japanese expert who is now in this country gathering ideas.

The Link-Belt Engineering Co., of Philadelphia, have recently been awarded contracts by the New York Central & Hudson River R. R. Co., for three complete locomotive coaling stations to be erected at Utica, Weehawken, and Kingston. These stations, to handle run-of-mine bituminous, will employ the Link-Belt carrier. They also have in course of construction a locomotive coaling station for the Lehigh Valley R. R. Co., at South Plainfield, N. J.. At this point lump anthracite, run-of-mine bituminous, and the small sizes of anthracite are to be handled.

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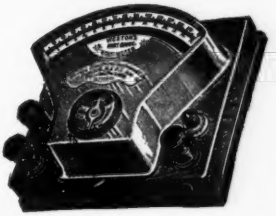

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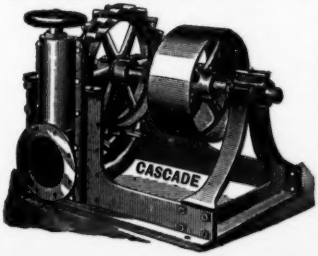

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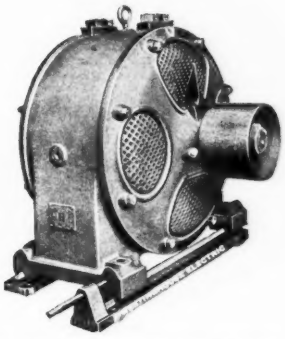

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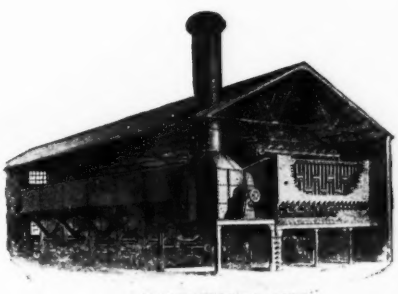

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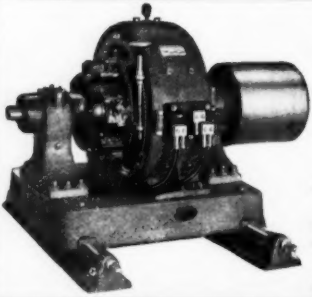

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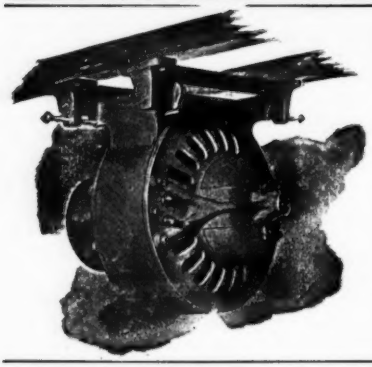

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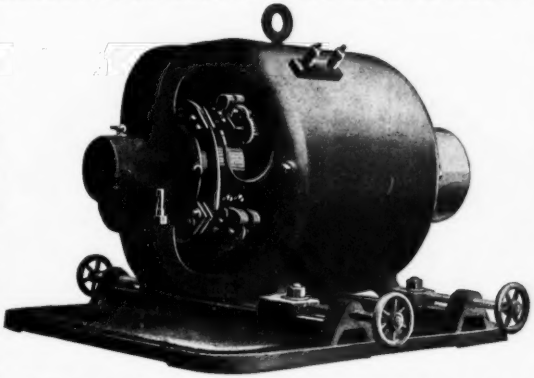

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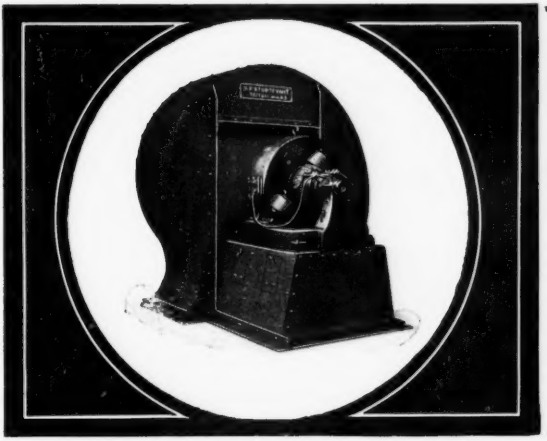

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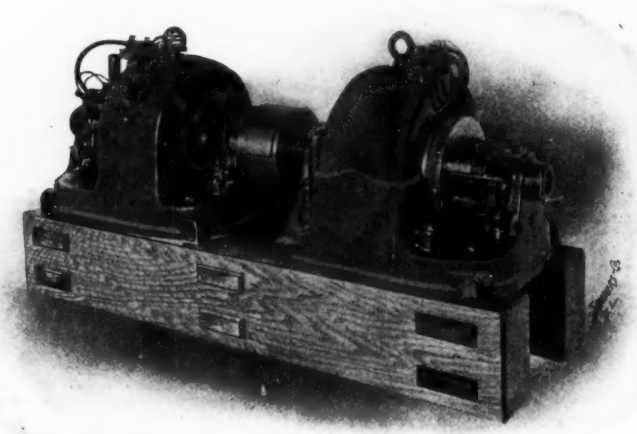

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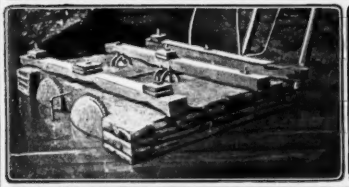

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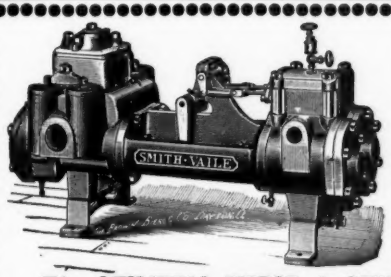

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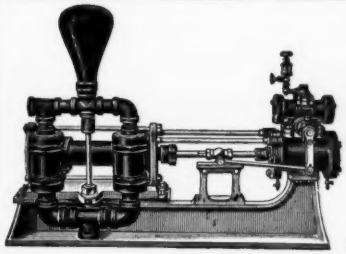

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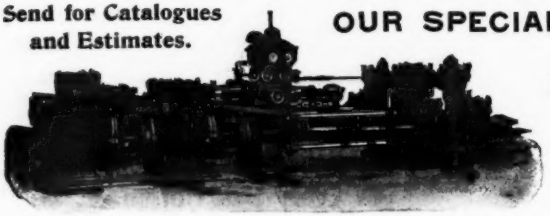

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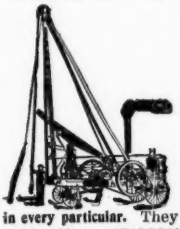

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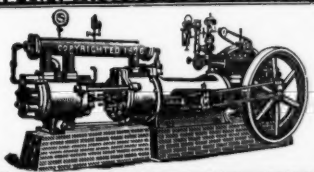

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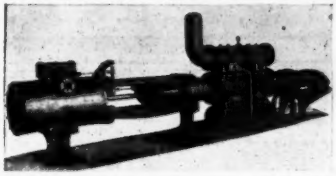

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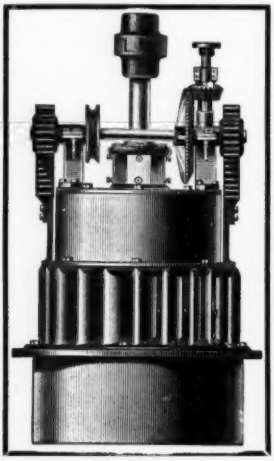

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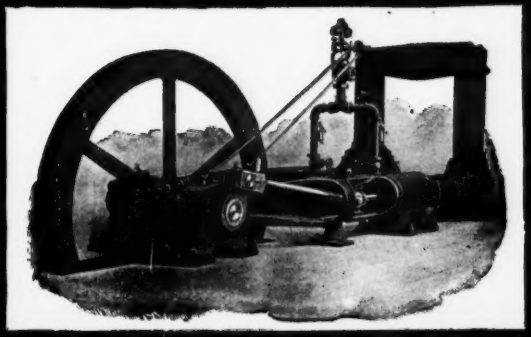

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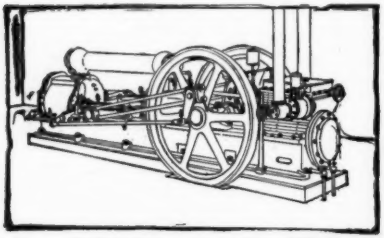

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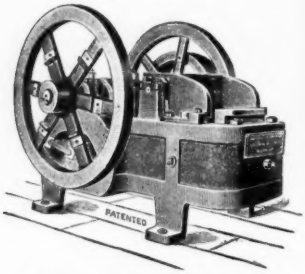

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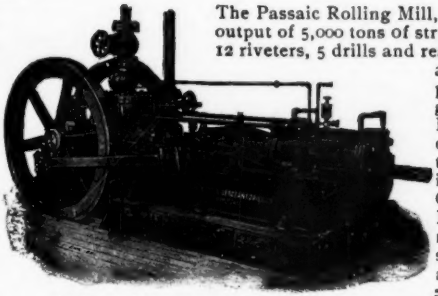

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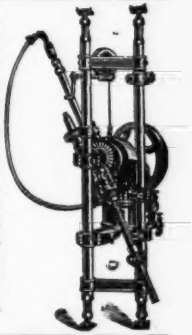

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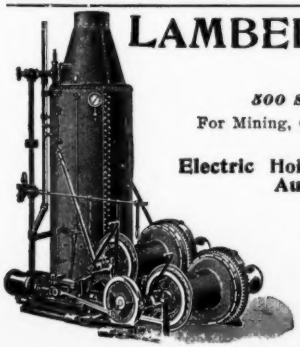

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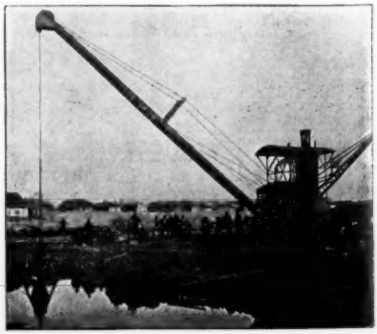

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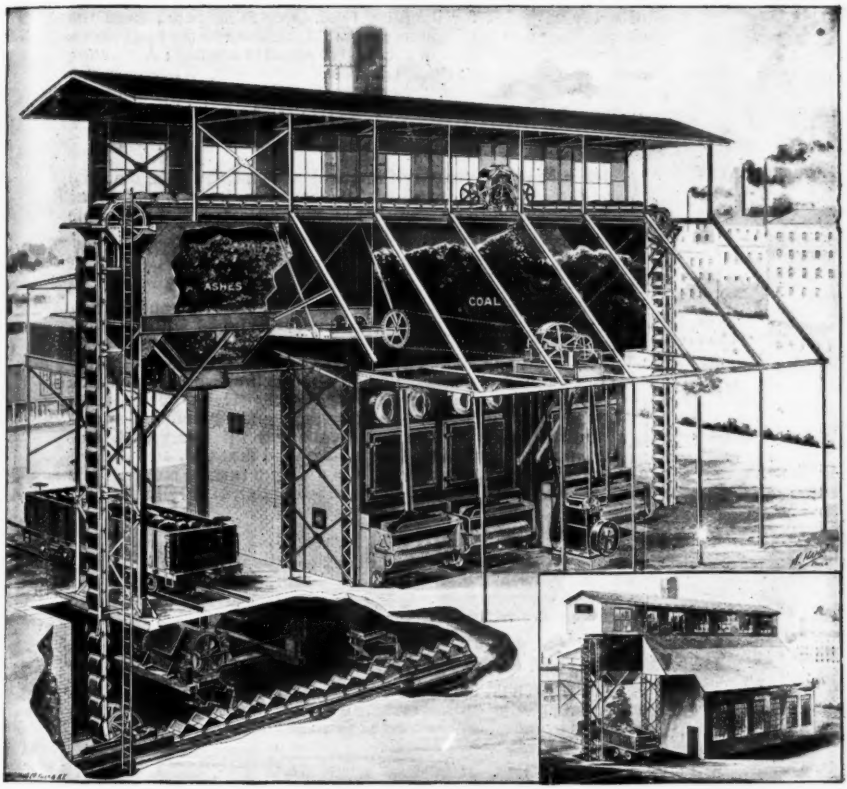

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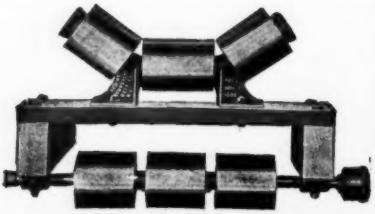

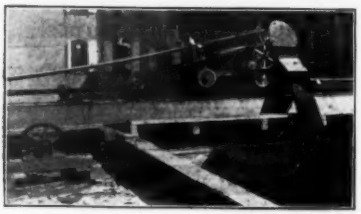

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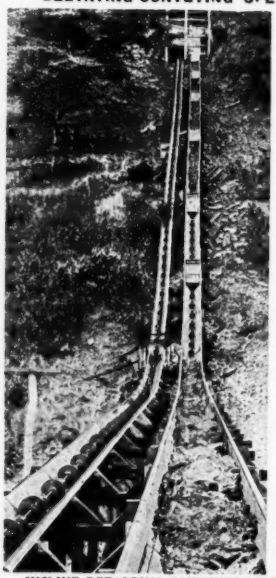

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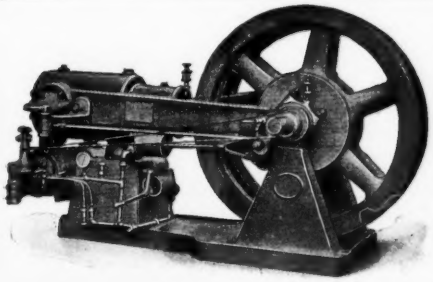

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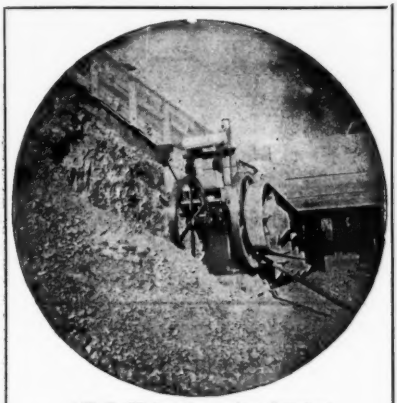

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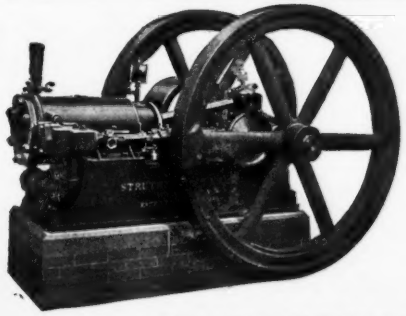

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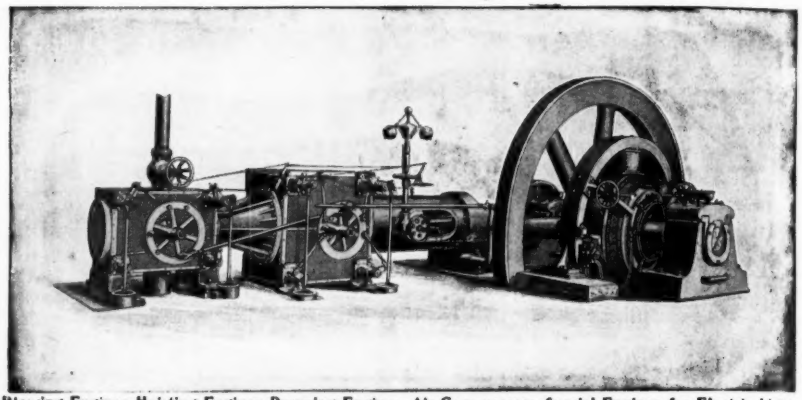

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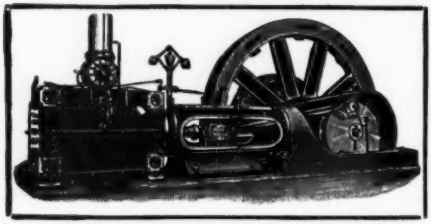

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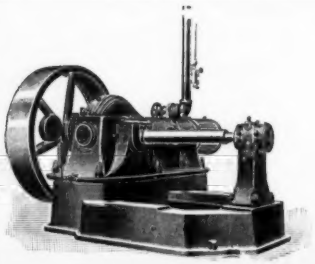

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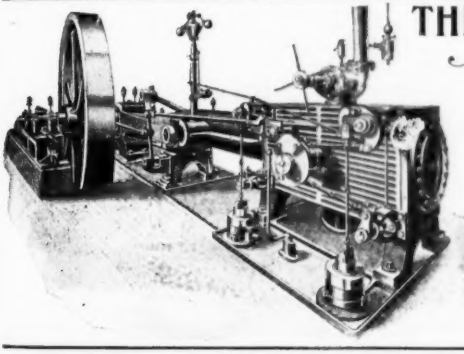

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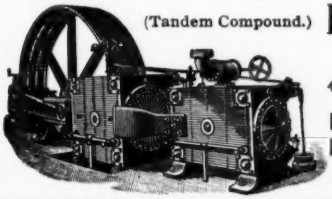

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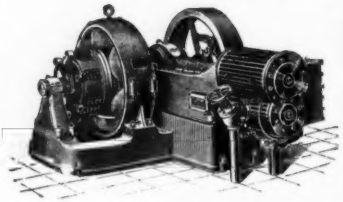

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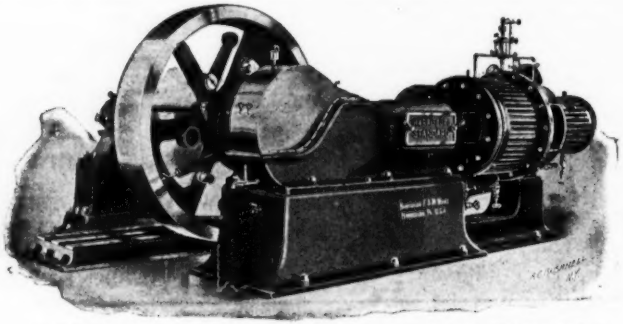

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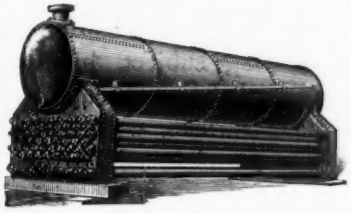

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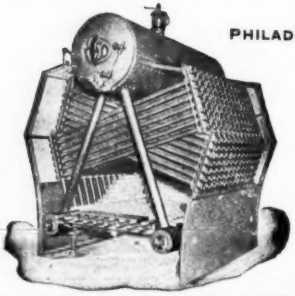

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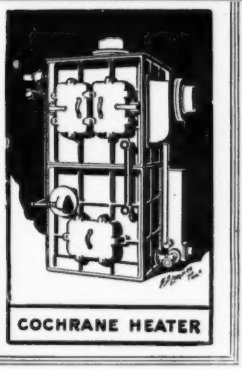

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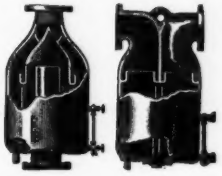

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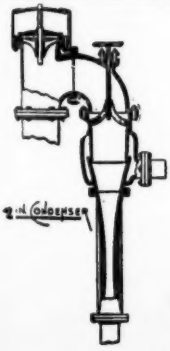

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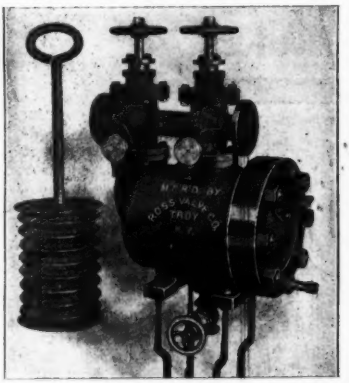

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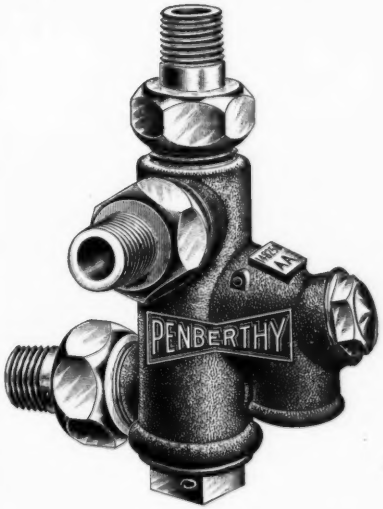

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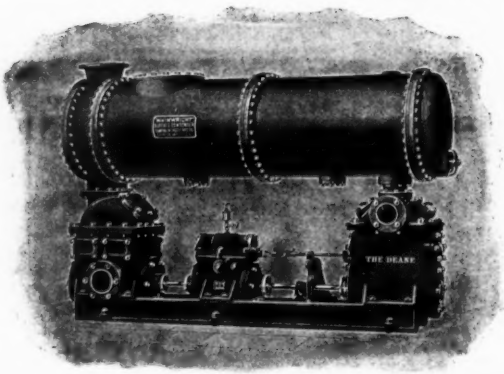

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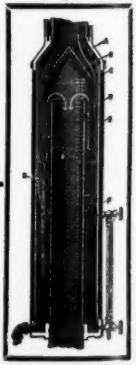

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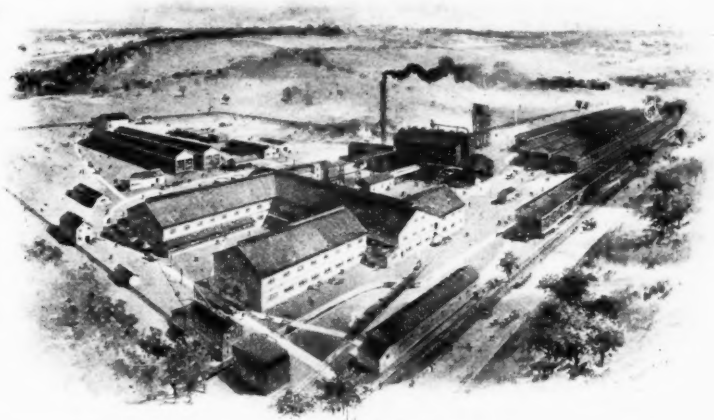

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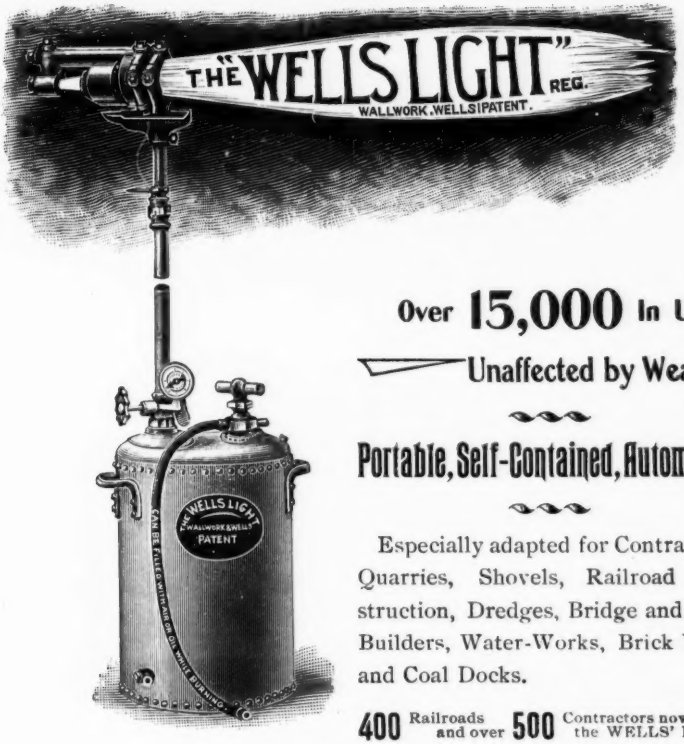

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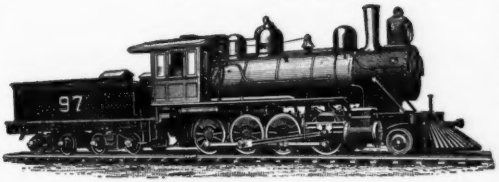

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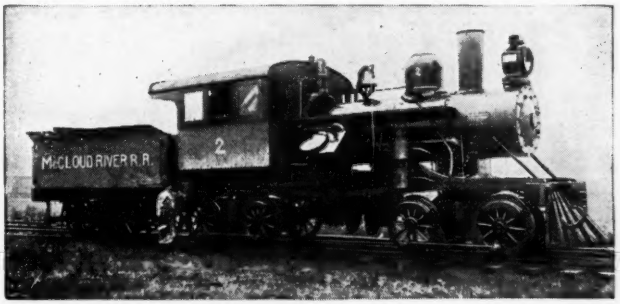

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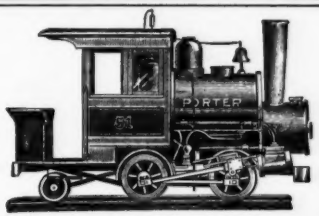

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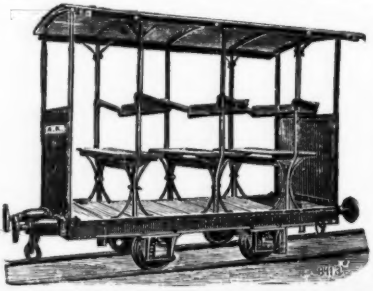

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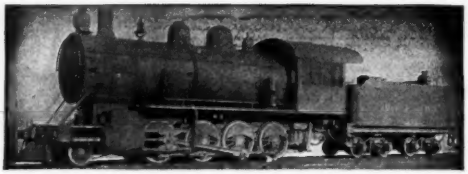

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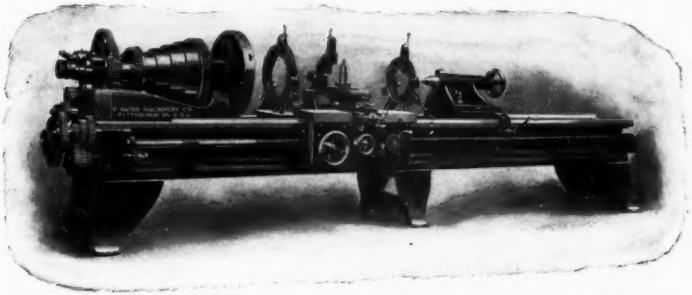

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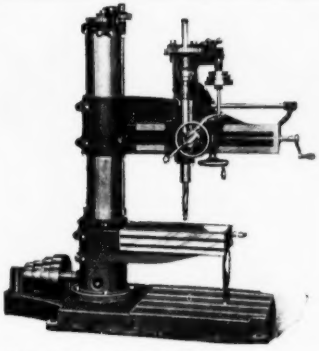

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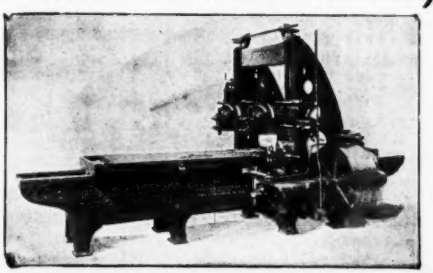

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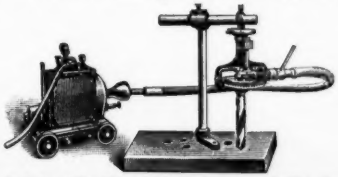

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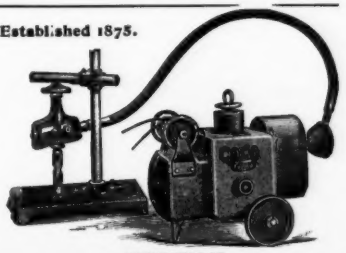

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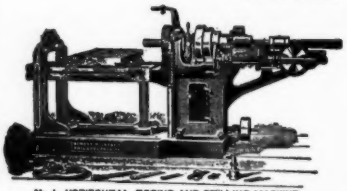

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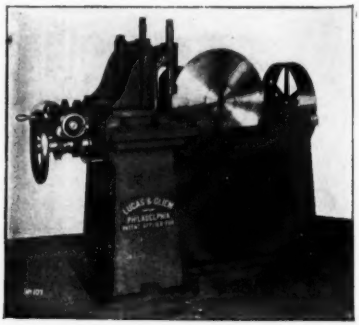

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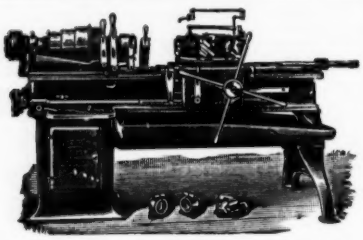

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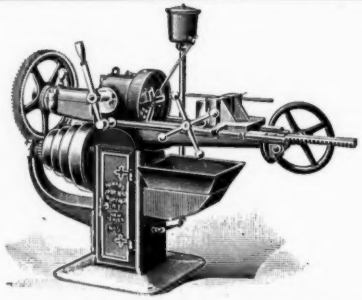

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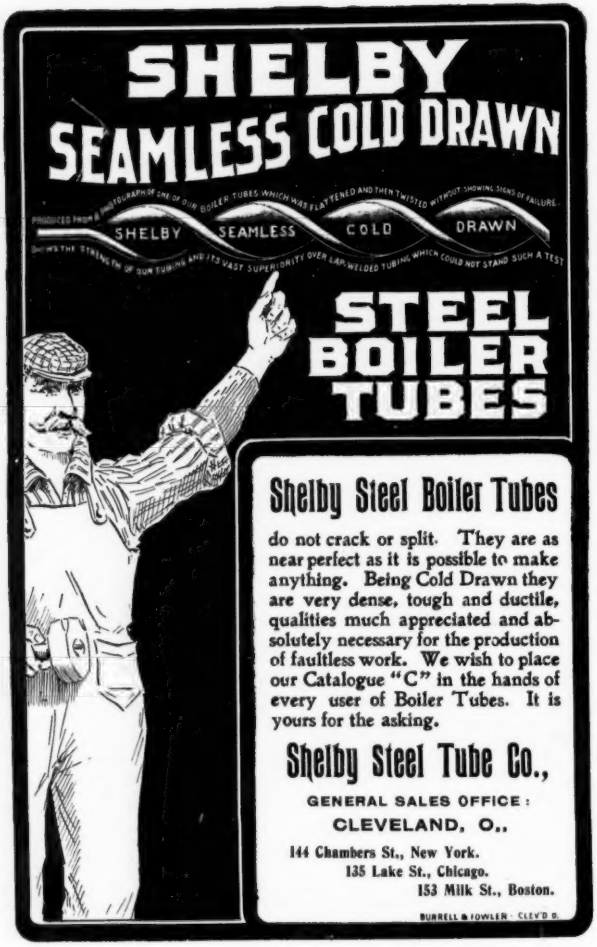
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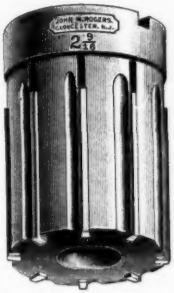

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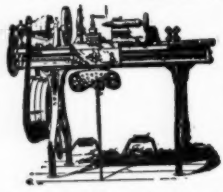

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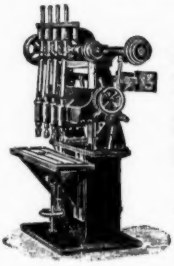

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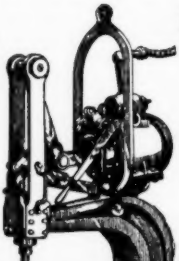

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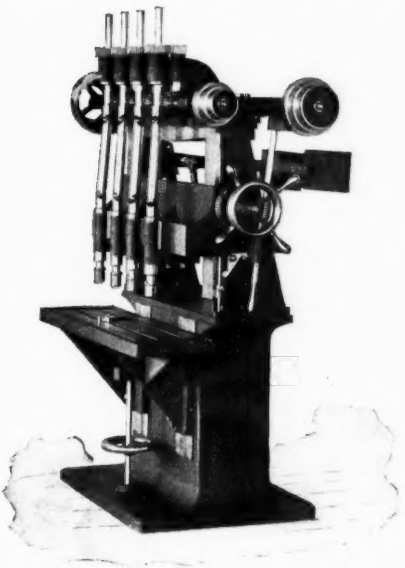

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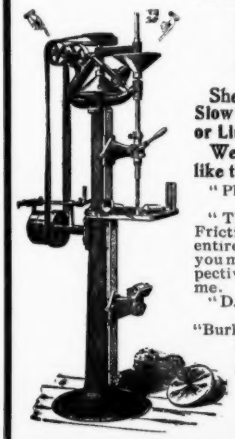

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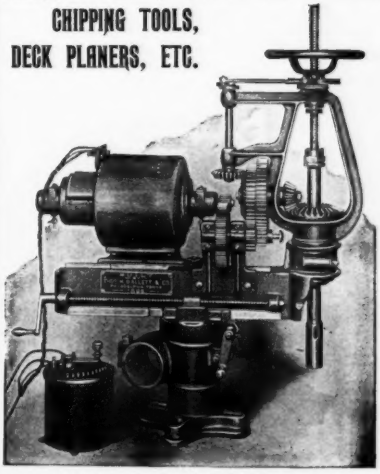

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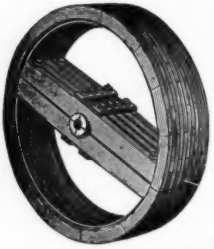

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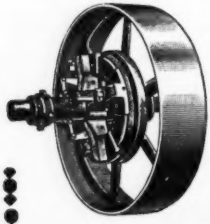

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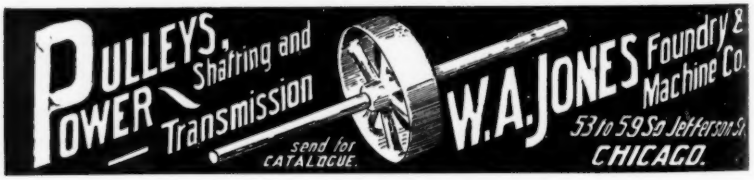

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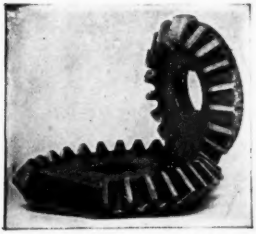

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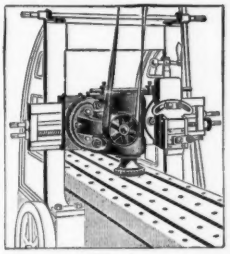

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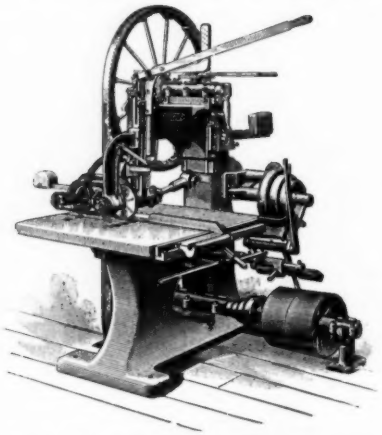

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Improved Wood Working Machinery.

Especially adapted for

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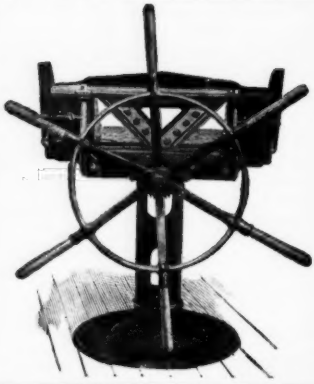

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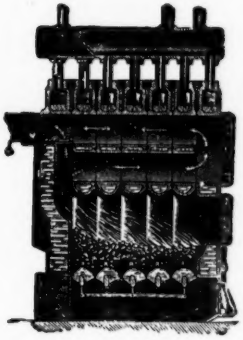

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The ENGINEERING INDEX published in this Magazine each month is an index to the current contents of some 200 of the leading engineering and technical journals and transactions of important societies published anywhere in the world in English, French, and German.

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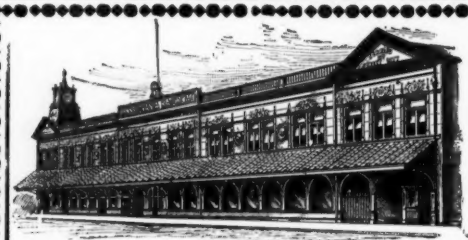

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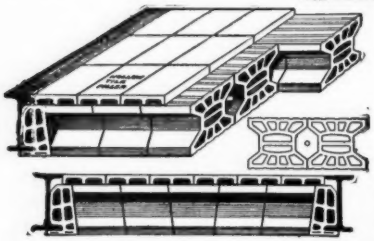

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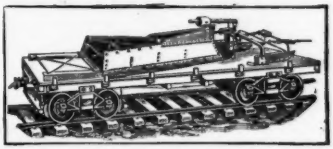

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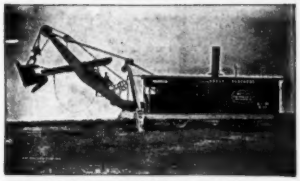

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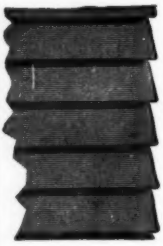

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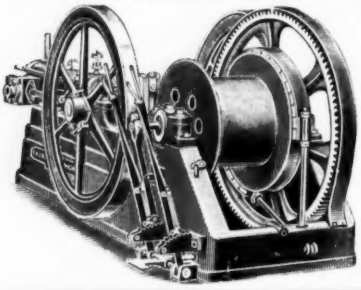

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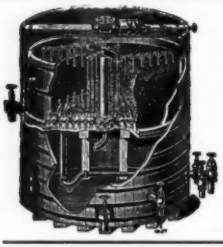

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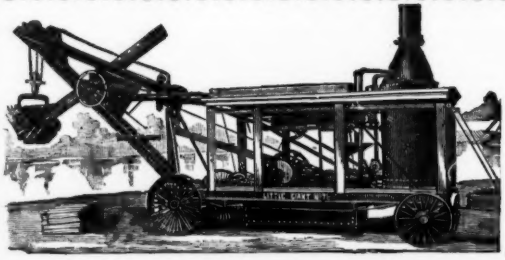

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AUTHORS AND PAPERS FOR MARCH.

RICHARD R. MABSON *(Gold-Mining Prospects in Rhodesia)*—Early in the nineties, Mr. Mabson directed attention in the *Statist* to the probabilities of South African gold production, and endorsed the opinion that the Rand deep levels would prove valuable. On the discredit of this belief in 1897, he visited Johannesburg, and after going through seven properties telegraphed to London assurances which contributed to the restoration of confidence. From April to September, 1899, he visited Rhodesia, to gather on the spot impressions as to the possibilities of gold production.

Since 1880, he has been associated with and editor of the *Statist*, London.

HUGO DIEMER *(Functions and Organisation of the Purchasing Department)*—Mr. Diemer's article—which, it is hoped, will be the precursor of other equally suggestive and valuable papers—embodies the fruits of a number of years' experience in the purchasing department of The Addyston Pipe and Steel Co., Cincinnati, Ohio; in the shops, purchasing department, and sales department of The Westinghouse Electric and Manufacturing Co., Pittsburg, Pa., and as purchasing agent and manager of the cost department of The Bullock Electric Manufacturing Co., Cincinnati, Ohio. All of these positions he filled with the highest credit. At present he occupies the chair of mechanical engineering at the Agricultural and Mechanical College, Greensboro, N. C.

ALTON D. ADAMS *(The Future of Electrical Supply)*—An electrical engineer, practising in Boston, Mass., and a member of the American Institute of Electrical Engineers.

A. STODOLA *(Steam-Engine Building in Switzerland)*—Professor Stodola was for some years actively engaged in engineering work. At present he occupies the chair of mechanical and steam engineering at the Polytechnikum, Zürich, where he is most highly regarded. In deference to his conception of professional etiquette, Prof. Stodola deprecates the publication of any extended professional record, and this brief note is made solely on the authority of this Magazine.

A. E. OUTERBRIDGE, JR. *(The Policy of Secretiveness in Industrial Works)*—A careful student of and most acceptable writer upon the sociological and industrial influences of modern machinery. His articles in former issues of THE ENGINEERING MAGAZINE, notably in May, Sept., Nov., and Dec., 1895, and January, 1897, are sufficient introduction to the public. Prof. Outerbridge's article on "Labor-Saving Machinery the Secret of Cheap Production," in the Prosperity Number of THE ENGINEERING MAGAZINE, has been widely noticed and most favorably reviewed.

FREDERICK A. HATCH *(The World's Supply of Copper)*—After three years' study in Germany, graduated at the Bonn University in 1886; served for several years on the Government Geological Survey of England and Wales; went to South Africa in 1892, where he joined the engineering staff of the Consolidated Gold-fields; visited Rhodesia in the company of John Hays Hammond in 1894; since 1895 has enjoyed an extensive practice as consulting mining engineer, visiting mining properties in various parts of South Africa, and latterly, in Canada, British Columbia, and the United States. In 1895 he published, in conjunction with Mr. J. A. Chalmers, the well-known book on the "Gold Mines of the Rand," and in 1897 a geological map of the Southern Transvaal.

AUTHORS AND PAPERS FOR MARCH.

BENJAMIN TAYLOR *(Ship-Building and Marine Engineering in 1899)*—A close observer and student of the broad influence of engineering progress and the economic effects of mechanical improvement. He is a contributor to many of the best periodicals, British and American. He is a Fellow of the Royal Geographical Society, a resident of Glasgow, and in close touch with the important engineering undertakings, accomplished or proposed, in Scotland.

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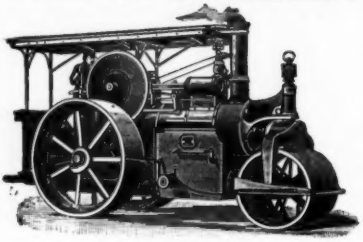

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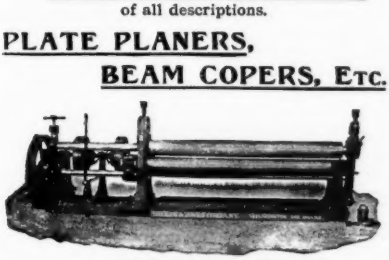

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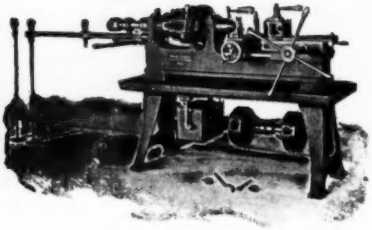

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Jos. Dixon Crucible Co., Jersey City, N. J.

Belting.
Aultman Company, Canton, Ohio.
Boston Belting Co., Boston, Mass.
Buhl Malleable Co., Detroit, Mich.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.
Main Belting Company, Philadelphia, Pa.
Robins Conveying Belt Co., Park Row Building, New York.
Chas. A. Schieren & Co., 45-51 Ferry St., New York.

Belt Lacing.
Bristol Co., Waterbury, Conn.

Bending Rolls.
Bethlehem Steel Co., South Bethlehem, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Bicycle Frame Drilling Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Bicycle Manufacturers' Machinery.
Fox Machine Co., Grand Rapids, Mich.

Blacksmiths' Tools.
Buffalo Forge Co., Buffalo, N. Y.
Hammacher, Schlemmer & Co., 209 Bowery, N.Y.

Blast Furnaces.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Blast Furnaces, Gas.
American Gas Furnace Co., Elizabeth, N. J.

Blowers.
American Blower Co., Detroit, Mich.
American Gas Furnace Co., 23 John St., New York.
Buffalo Forge Co., Buffalo, N. Y.
Gates Iron Works, Chicago, Ill.
Sprague Electric Co., 527 W. Thirty-fourth St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Boilers.
American Well Works, Aurora, Ill.

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Atlantic Works, East Boston, Mass.
Aultman Company, Canton, Ohio.
Edw. P. Allis Co., Milwaukee, Wis.
Clonbrock Steam Boiler Co., Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Heine Safety Boiler Co., St. Louis, Mo.
New York Safety Steam Power Co., 107 Liberty St., N. Y.
Pittsburg Locomotive Works, Pittsburg, Pa.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Star Drilling Machine Co., Akron, Ohio.
Stearns Manufacturing Co., Erie, Pa.
Taunton Locomotive Mfg. Co., Taunton, Mass.
The Stirling Co., Chicago, Ill.
Thorpe, Platt & Co., New York.
Robt. Wetherill & Co., Chester, Pa.

Boiler Fronts and Fittings.
Vulcan Iron Works, Toledo, Ohio.
Walworth Manufacturing Co., Boston, Mass.

Boiler Compounds.
Chicago Boiler Cleaner Co., 827 Monadnock Block, Chicago, Ill.
Dearborn Drug & Chemical Works, 29 Rialto, Chicago, Ill.

Boiler Inspectors.
Hartford S. B. I. & Ins. Co., Hartford, Conn.

Boiler-Makers' Tools.
Hammacher, Schlemmer & Co., 209 Bowery, N.Y.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.

Bolt Cutters.
Acme Machinery Co., Cleveland, Ohio.
American Tool Works Co., Cincinnati, Ohio.
John M. Rogers, Boat, Gauge and Drill Works, Gloucester City, N. J.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Bolt and Rivet Headers.
Acme Machinery Co., Cleveland, Ohio.

Books.
Henry Carey Baird & Co., 810 Walnut St., Philadelphia, Pa.
Engineering Magazine Press, Ltd., 120-122 Liberty St., New York.
Philadelphia Book Co., Philadelphia, Pa.

Boring Machines.
American Tool Works Co., Cincinnati, Ohio.
The Egan Co., 271-291 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-279 West Front St., Cincinnati, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Box Makers' Machinery.
Egan Co., 271-279 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-279 West Front St., Cincinnati, Ohio.

Brass Working Machine Tools.
Warner & Swasey, Cleveland, Ohio.

Bricks.
Henry Maurer & Son, 420 E. 23d St., New York.

Brick and Tile Machinery.
American Blower Co., Detroit, Mich.
F. D. Cummer & Son Co., Cleveland, Ohio.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.

Bridge Builders.
Passaic Rolling Mill Co., Paterson, N. J.

Bridge Pins.
Bethlehem Steel Co., South Bethlehem, Pa.

Bridge Railing.
Chester B. Albree, Allegheny, Pa.

Builders' Elevators.
Lidgerwood Mfg. Co., 96 Liberty St., New York.

Building Materials.
Chester B. Albree, Allegheny, Pa.
T. H. Brooks Co., Cleveland, Ohio.
Cincinnati Corrugating Co., Piqua, Ohio.
Detroit Graphite Mfg. Co., Detroit, Mich.
Joseph Dixon Crucible Co., Jersey City, N. J.
H. W. Johns Mfg. Co., 100 William St., N. Y.
Henry Maurer & Son, 420 E. 23d St., New York.
Passaic Rolling Mill Co., Paterson, N. J.
Pittsburg Terra Cotta Lumber Co., Pittsburg, Pa.

Cable-Railway Driving-Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
Robt. Wetherill & Co., Chester, Pa.

Cables, Electric and Submarine.
Okonite Co., Ltd., 253 Broadway, New York.
John A. Roebling's Sons Co., Trenton, N. J.

Cableways.
Fraser & Chalmers, Chicago, Ill.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
John A. Roebling's Sons Co., Trenton, N. J.

Cables, Wire.
American Steel & Wire Co., Chicago, Ill.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
John A. Roebling's Sons Co., Trenton, N. J.
Trenton Iron Co., Trenton, N. J.

Calcining and Drying Machines.
F. D. Cummer & Son Co., Cleveland, Ohio.

Calculating Machines.
Felt & Tarrant Mfg. Co., Chicago, Ill.

Cams and Tappets.
Chrome Steel Works, Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.

Card Index Files.
Library Bureau, Boston, Mass.
Rockwell & Rupel Co., 53 La Salle St., Chicago.

Car Brakes.
Dorner Truck & Mfg. Co., Cleveland, Ohio.

Car Shop Machinery.
Egan Co., 271-279 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-279 West Front St., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.

Car Wheel Foundry Equipment.
Whiting Foundry Equipment Co., Harvey, Ill.

Carriage and Wagon Machinery.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Egan Co., 271-279 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-279 West Front St., Cincinnati, Ohio.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

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Cast Iron Pipe.
U. S. Cast Iron Pipe & Fdy. Co., Philadelphia, Pa.

Castings, Iron and Steel.
Aultman Company, Canton, Ohio.
Bethlehem Steel Co., South Bethlehem, Pa.
Edw. P. Allis Co., Milwaukee, Wis.
Stanley G. Flagg & Co., Philadelphia, Pa.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Walworth Manufacturing Co., Boston, Mass.

Cement.
Atlas Portland Cement Co., 143 Liberty St., New York.
Kelley Island Lime and Transport Co., Cleveland, Ohio.

Cement Separators.
Jeffrey Manufacturing Co., Columbus, Ohio.

Centrifugal Pumps.
Bucyrus Co., So. Milwaukee, Wis.

Centrifugals.
Henry G. Morris, Philadelphia, Pa.

Chain Belting.
Aultman Company, Canton, Ohio.
Buhl Malleable Co., Detroit, Mich.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.

Chemicals.
Harrison Bros. & Co., Inc., Philadelphia, Pa.
Roessler & Hasslacher Chemical Co., 100 William St., New York.

Chemical Works Machinery.
Atlantic Works, East Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Chemists—Water and Oil.
Dearborn Drug & Chemical Works, 29 Rialto, Chicago, Ill.

Chloride of Lime.
Roessler & Hasslacher Chem. Co., 100 William St., New York.

Chucks.
American Tool Works Co., Cincinnati, Ohio.

Clay-Working Machinery.
American Blower Co., Detroit, Mich.
Aultman Company, Canton, Ohio.
F. D. Cummer & Son Co., Cleveland, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.
Vulcan Iron Works, Toledo, Ohio.

Coal and Ashes-Handling Machinery.
Aultman Company, Canton, Ohio.
C. W. Hunt Co., West New Brighton, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.
Robins Conveying Belt Co., Park Row Building, New York.

Coal-Mining Machinery.
Buffalo Forge Co., Buffalo, N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
Arthur Koppel, 68 Broad St., New York.
John H. McGowan Co., Cincinnati, Ohio.
C. W. Hunt Co., West New Brighton, New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, New York.
Robins Conveying Belt Co., Park Row Building, New York.
Sullivan Machinery Co., Chicago, Ill.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Coal Screens.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Manufacturing Co., Columbus, Ohio.

Coal-Washing Machinery.
Jeffrey Mfg. Co., Columbus, Ohio.

Cold Saws.
Lucas & Gliem, 1037 Ridge Ave., Philadelphia, Pa.
Q & C Company, Chicago, Ill.

Compressed Air Hoists and Motors.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.

Compressed Air Shop Tools.
Clayton Air Compressor Works, 20 Cortlandt St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.

Concentrators and Pulverizers.
F. D. Cummer & Son Co., Cleveland, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Condensers.
Edw. P. Allis Co., Milwaukee, Wis.
Wm. Baragwanath & Son, Chicago, Ill.
Fraser & Chalmers, Chicago, Ill.
Laidlaw-Dunn-Gordon Co., Cincinnati, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Contractors' Dump Cars, etc.
Gates Iron Works, Chicago, Ill.
Arthur Koppel, 68 Broad St., New York.

Contractors' Supplies.
Contractors' Plant Mfg. Co., Buffalo, N. Y.
Lambert Hoisting Engine Co., Newark, N. J.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.
Pelton Engineering Co., Cleveland, Ohio.
Robins Conveying Belt Co., Park Row Building, New York.
Stearns Mfg. Co., Erie, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Vulcan Iron Works, Toledo, Ohio.
Watson & Stillman Co., 210 E. 43d St., New York.
Wells Light Mfg. Co., 44 Washington St., New York.

Converters.
Riter-Conley Mfg. Co., Pittsburg, Pa.

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Conveying Machinery.
Aultman Company, Canton, Ohio.
Buhl Malleable Co., Detroit, Mich.
Frick Company, Waynesboro, Pa.
C. W. Hunt Co., West New Brighton, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Link-Belt Engineering Co., Philadelphia, Pa.
John A. Mead Mfg. Co., 3 Broadway, New York.
Robins Conveying Belt Co., Park Row Building, New York.

Copper.
Orford Copper Co., 37 Wall St., New York.

Corrugated Copper Tubes.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Corrugated Iron.
Cincinnati Corrugating Co., Piqua, Ohio.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Cranes.
Brown Hoisting & Conveying Machine Co., Cleveland, Ohio.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Wm. Sellers & Co., Philadelphia, Pa.
Whiting Foundry Equipment Co., Harvey, Ill.
R. D. Wood & Co., Philadelphia, Pa.

Crank Pins.
Bethlehem Steel Co., South Bethlehem, Pa.

Crusher Plates.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Crushers—Ore, Phosphate, Rock.
Edw. P. Allis Co., Milwaukee, Wis.
Aultman Company, Canton, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Sturtevant Mill Co., Boston, Mass.

Cupolas.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Whiting Foundry Equipment Co., Harvey, Ill.

Cyanide.
Roessler & Hasslacher Chemical Co., New York.

Cylinder Boring and Facing Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Diamond Drills.
American Well Works, Aurora, Ill.
M. C. Bullock Mfg. Co., Chicago, Ill.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Rand Drill Co., 100 Broadway, New York.
Sullivan Machinery Co., Chicago, Ill.

Dies and Die Forgings.
Walworth Manufacturing Co., Boston, Mass.

Die and Drill Steel.
Hobson, Seaman & Co., 97 John St., New York.
Wm. Jessop & Sons, Ltd., 91 John St., New York.

Digesters.
Atlantic Works, East Boston, Mass.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Drawing Instruments and Materials.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Buff & Buff Mfg Co., 506-510 Atlantic Ave., Boston, Mass.
Keuffel & Esser Co., New York.
Queen & Co., Inc., Philadelphia, Pa.

Dredging Machines.
Aultman Company, Canton, Ohio.
A. B. Bowers, San Francisco, Cal.
Bucyrus Co., So. Milwaukee, Wis.
Jeffrey Mfg. Co., Columbus, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
New York Dredging Co., 61 Park Row, N. Y.
Vulcan Iron Works, Toledo, Ohio.

Drill Grinder.
Fuller Mfg. Co., Kalamazoo, Mich.

Drill Presses.
American Tool Works Co., Cincinnati, Ohio.

Drills—Rock and Coal.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
M. C. Bullock Mfg. Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Rand Drill Co., 100 Broadway, New York.
Star Drilling Machine Co., Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Drilling Machines.
U. Baird Machinery Co., 723-725 Water St., Pittsburg, Pa.
W. F. & John Barnes Co., Rockford, Ill.
Bement, Miles & Co., Philadelphia, Pa.
Bickford Drill and Tool Co., Cincinnati, Ohio.
Buffalo Forge Co., Buffalo, N. Y.
Cincinnati Milling Machine Co., Cincinnati, O.
Thos. H. Dallett & Co., Philadelphia, Pa.
Foote, Burt & Co., Cleveland, Ohio.
Fox Machine Co., Grand Rapids, Mich.
Hill, Clarke & Co., Oliver St., Boston, Mass.
Knecht Bros. Co., Cincinnati, Ohio.
Niles Tool Works, Hamilton, Ohio.
Norton & Jones Machine Tool Works, Plainville, Conn.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
John M. Rogers, Boat, Gauge and Drill Works, Gloucester City, N. J.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.

Drop Forging Plants.
Billings & Spencer Co., Hartford, Conn.

Drop Hammers.
Billings & Spencer Co., Hartford, Conn.
Long & Allstatter Co., Hamilton, Ohio.

Drying and Calcining Machines.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
F. D. Cummer & Son Co., Cleveland, Ohio.
Gates Iron Works, Chicago, Ill.
Harrison Safety Boiler Works, Philadelphia, Pa.
Jeffrey Mfg. Co., Columbus, Ohio.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Dump Cars.
Goodwin Car Co., 96 Fifth Ave., New York.

Dust Collectors.
Allington & Curtis Co., 1639 Monadnock, Chicago, Ill.

Dynamos.
American Engine Co., Bound Brook, N. J.
Bullock Electric Mfg. Co., Cincinnati, Ohio.

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C & C Electric Co., 143 Liberty St., New York.
Central Electric Co., 265-269 Fifth Ave., Chicago, Ill.
Commercial Electric Co., Indianapolis, Ind.
Eddy Electric Mfg. Co., Windsor, Conn.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Pelton Engineering Co., Cleveland, Ohio.
Sprague Electric Co., 527 West Thirty-fourth St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Electrical Machinery and Supplies.

American Engine Co., Bound Brook, N. J.
Bristol Co., Waterbury, Conn.
Bullock Electric Mfg. Co., Cincinnati, Ohio.
C & C Electric Co., 143 Liberty St., New York.
Central Electric Co., 265-269 Fifth Ave., Chicago, Ill.
Commercial Electric Co., Indianapolis, Ind.
Eddy Electric Mfg. Co., Windsor, Conn.
Eureka Electric Co., 157 So. Canal St., Chicago, Ill.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Pelton Engineering Co., Cleveland, Ohio.
Sprague Electric Co., 527 West Thirty-fourth St., New York.
Frank H. Stewart & Co., 35 No. 7th St., Phila., Pa.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Tucker Manufacturing Co., York, Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Weston Electrical Instrument Co., Newark, N. J.

Electric Locomotives.

Baldwin Locomotive Works, Philadelphia, Pa.
General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
H. K. Porter Co., Pittsburg, Pa.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Elevator Guards and Screens.

Harrington & King Perforating Co., Chicago, Ill.

Elevators.

Aultman Co., Canton, Ohio.
Buhl Malleable Co., Detroit, Mich.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
John A. Mead Mfg. Co., 3 Broadway, New York.
R. Poole & Son Co., Baltimore, Md.
Sprague Electric Co., 527 W. Thirty-fourth St., New York.
Triumph Electric Co., Cincinnati, Ohio.
Whiting Foundry Equipment Co., Harvey, Ill.
R. D. Wood & Co., Philadelphia, Pa.

Emery Wheels.

Carborundum Co., Niagara Falls, N. Y.

Emery-Wheel Machinery.

Stow Flexible Shaft Co., Philadelphia, Pa.

Engineers.

Daniel Ashworth, 326 Fourth Ave., Pittsburg, Pa.
A. B. Bowers, San Francisco, Cal.
William M. Brewer, Molson's Bank Building, Vancouver, B. C.
Consolidated Public Works Co., 222 South Third St., Philadelphia, Pa.
Madison Cooper, 410 No. First St., Minneapolis, Minn.
L. B. Darling, 70 Sabin St., Providence, R. I.
W. Dusedau, Brooklyn, N. Y.
Julian Kennedy, Pittsburg, Pa.
David Lamond, 710 Ferguson Block, Pittsburg, Pa.
N. Y. University Testing Laboratory, New York.
Pelton Engineering Co., Cleveland, Ohio.
Alexander Potter, New York and Pittsburg.
C. L. Redfield, Chicago, Ill.
Sydney F. Reynolds, Torry, Pa.
H. B. Roelker, 41 Maiden Lane, New York.
Stillman & Hall, Ltd., 15 Wall St., New York.
Tower & Wallace, Townsend Bldg., New York.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Engineering Appliances.

The Lukenheimer Co., Cincinnati, Ohio.

Engineering Instruments.

Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Buff & Buff, 506-510 Atlantic Ave., Boston, Mass.
Keuffel & Esser Co., New York.
Queen & Co., Inc., Philadelphia, Pa.

Engines, Blowing.

Edw. P. Allis Co., Milwaukee, Wis.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Fraser & Chalmers, Chicago, Ill.
Sprague Electric Co., 527 W. Thirty-fourth St., New York.

Engines—Gas, Gasoline, and Petroleum.

American Well Works, Aurora, Ill.
Aultman Company, Canton, Ohio.
Charter Gas Engine Co., 324 Second St., Sterling, Ill.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Priestman & Co., Bourse Bldg., Philadelphia, Pa.
Struthers, Wells & Co., Warren, Pa.
Weber Gas & Gasoline Engine Co., 428 Southwest Boulevard, Kansas City, Mo.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Engines, Marine.

Atlantic Works, East Boston, Mass.
Marine Iron Works, Station A, Chicago, Ill.

Engines, Stationary.

Edw. P. Allis Co., Milwaukee, Wis.
American Blower Co., Detroit, Mich.
American Engine Co., Bound Brook, N. J.
American Well Works, Aurora, Ill.
Aultman Company, Canton, Ohio.
Ball Engine Co., Erie, Pa.
Buffalo Forge Co., Buffalo, N. Y.
Bullock Mfg. Co., M. C., Chicago, Ill.
Frick Company, Waynesboro, Pa.
Gates Iron Works, Chicago, Ill.
Harrisburg Foundry and Machine Co., Harrisburg, Pa.
Hooven, Owens & Rentschler Co., Hamilton, Ohio.
New York Safety Steam Power Co., 107 Liberty St., N. Y.
Star Drilling Machine Co., Akron, Ohio.
Stearns Manufacturing Co., Erie, Pa.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Webster, Camp & Lane Machine Co., Akron, Ohio.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Robert Wetherill & Co., Chester, Pa.

Engravers.

A. Mugford, 120 Liberty St., New York.

Excavators.

Aultman Company, Canton, Ohio.
A. B. Bowers, San Francisco, Cal.
Bucyrus Co., So. Milwaukee, Wis.
Jeffrey Mfg. Co., Columbus, Ohio.
Marion Steam Shovel Co., Marion, Ohio.

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New York Dredging Co., 61 Park Row, New York.
Robins Conveying Belt Co., Park Row Building, New York.
Vulcan Iron Works, Toledo, Ohio.

Exhaust Fans.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Exhaust Heads.
Direct Separator Co., Syracuse, N. Y.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Fans, Cooling and Heating.
Sprague Electric Co., 20 Broad St., New York.

Fans, Electric.
Pelton Engineering Co., Cleveland, Ohio.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Fans, Ventilating.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Fraser & Chalmers, Chicago, Ill.
Pelton Engineering Co., Cleveland, Ohio.
Sprague Electric Co., 527 W. Thirty-fourth St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Feed-Water Filters.
Ross Valve Co., Troy, N. Y.

Feed-Water Heaters.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
Goubert Mfg. Co., 14 Church St., New York.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Manufacturing Co., Springfield, Ohio.
John H. McGowan Co., Cincinnati, Ohio.
Taunton Locomotive Mfg. Co., Taunton, Mass.
Robt. Wetherill & Co., Chester, Pa.

Feed-Water Purifiers.
Fraser & Chalmers, Chicago, Ill.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Manufacturing Co., Springfield, Ohio.

Ferro-Silicon.
Carborundum Co., Niagara Falls, N. Y.

Fertilizer Machinery.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.

Files and Rasps.
G. & H. Barnett Co., Philadelphia, Pa.

Filters.
New York Filter Mfg. Co., New York.

Fire Hydrants.
R. D. Wood & Co., Philadelphia, Pa.

Flanges.
Latrobe Steel Co., 1200 Girard Bldg., Philadelphia, Pa.

Flexible Shafts.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Floor and Sidewalk Lights.
T. H. Brooks & Co., Cleveland, Ohio.

Flour-Mill Machinery.
Edw. P. Allis Co., Milwaukee, Wis.

Flue Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Flue Cutters and Rollers.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.

Fly Wheels.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
R. Poole & Son Co., Baltimore, Md.

Forges.
Buffalo Forge Co., Buffalo, N. Y.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Forgings, Iron and Steel.
Chester B. Albree, Allegheny, Pa.
Bethlehem Steel Co., South Bethlehem, Pa.
Billings & Spencer Co., Hartford, Conn.
Keystone Drop Forge Co., Philadelphia, Pa.
Strieby & Foote, Newark, N. J.
Wyman & Gordon, Worcester, Mass.

Forming Machines.
Long & Allstatter Co., Hamilton, Ohio.

Foundry Equipment.
Whiting Foundry Equipment Co., Harvey, Ill.

Friction Clutches.
Eastern Machinery Co., New Haven, Conn.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.
R. Poole & Son Co., Baltimore, Md.
Reeves Pulley Co., Columbus, Ind.

Furnaces.
Whiting Foundry Equipment Co., Harvey, Ill.

Furnace Builders.
Julian Kennedy, Pittsburg, Pa.

Furniture.
Library Bureau, Boston, Mass.
Rockwell & Rupel Co., 53 La Salle St., Chicago.

Furniture and Chair Machinery.
Egan Co., 271-921 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.

Gages—Pressure, Steam, Water, etc.
Bristol Co., Waterbury, Conn.
Hohman & Maurer Mfg. Co., 53 Elizabeth St., Rochester, N. Y.
Walworth Manufacturing Co., Boston, Mass.

Gas Exhausters.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Gas Fixtures.
Walworth Manufacturing Co., Boston, Mass.

Gas Holders.
Riter-Conley Mfg. Co., Pittsburg, Pa.
United Gas Improvement Co., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Gas Machines and Generators.
American Gas Furnace Co., 23 John St., N. Y.
United Gas Improvement Co., Philadelphia, Pa.
Walworth Manufacturing Co., Boston, Mass.

Gas Plants.
American Gas Furnace Co., 23 John St., New York.
Riter-Conley Mfg. Co., Pittsburg, Pa.
United Gas Improvement Co., Philadelphia, Pa.

Gas Producers.
Riter-Conley Mfg. Co., Pittsburg, Pa.
United Gas Improvement Co., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Gas-Works Machinery.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.
United Gas Improvement Co., Philadelphia, Pa.

Gate Valves.
Jenkins Bros., 71 John St., New York.
The Lukenheimer Co., Cincinnati, Ohio.

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Walworth Manufacturing Co., Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Gear Cutters.
Hugo Bilgram, 440 No. 12th St., Philadelphia, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Gearing.
Edw. P. Allis Co., Milwaukee, Wis.
Hugo Bilgram, 440 No. 12th St., Philadelphia, Pa.
Jeffrey Mfg. Co., Columbus, Ohio.
Morse, Williams & Co., Philadelphia, Pa.
New Process Rawhide Co., Syracuse, N. Y.
R. Poole & Son Co., Baltimore, Md.
Stow Flexible Shaft Co., Philadelphia, Pa.

Generating Sets.
Pelton Engineering Co., Cleveland, Ohio.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Girders.
Chester B. Albree, Allegheny, Pa.
Berlin Iron Bridge Co., East Berlin, Conn.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Glass Polishing Machines.
Stow Flexible Shaft Co., Philadelphia, Pa.

Grain Elevator Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Engineering Co., Philadelphia, Pa.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Robins Conveying Belt Co., Park Row Building, New York.

Grates.
Vulcan Iron Works, Toledo, Ohio.

Grinding and Polishing Machinery.
American Tool Works Co., Cincinnati, Ohio.
Landis Tool Co., Waynesboro, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.

Grips, Cable Railways.
Robt. Wetherill & Co., Chester, Pa.

Hangers—See Pulleys.

Heating and Ventilating Apparatus.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Sprague Electric Co., 527 W. Thirty-fourth St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Heaters, Steam and Hot Water.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
H. B. Smith Co., 137 Center St., New York.
Walworth Manufacturing Co., Boston, Mass.

Helve Hammers.
Long & Alstatter Co., Hamilton, Ohio.

Hoisting Engines and Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
Aultman Company, Canton, Ohio.
Brown Hoisting & Conveying Machine Co., Cleveland, Ohio.
Contractors' Plant Mfg. Co., Buffalo, N. Y.
Cooper, Hewitt & Co., 17 Burling Slip, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
C. W. Hunt Co., West New Brighton, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Lambert Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Stearns Manufacturing Co., Erie, Pa.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.
Weber Gas & Gasoline Engine Co., 428 Southwest Boulevard, Kansas City, Mo.
Webster, Camp & Lane Machine Co., Akron, O.

Hollow Bricks.
Henry Maurer & Son, 420 E. 23d St., New York.
Pittsburg Terra Cotta Lumber Co., Pittsburg, Pa.

Hollow Chisel Mortisers.
The Egan Co., 271-291 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.

Hydrants.
R. D. Wood & Co., Philadelphia, Pa.

Hydraulic Cement.
Atlas Cement Co., 143 Liberty St., New York.
Kelley Island Lime and Transport Co., Cleveland, Ohio.

Hydraulic Machinery.
John H. McGowan Co., Cincinnati, Ohio.
S. Morgan Smith Co., York, Pa.
R. Poole & Son Co., Baltimore, Md.
Watson & Stillman Co., 210 E. 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

Ice-Making Machinery.
Frick Company, Waynesboro, Pa.
H. B. Roelker, 41 Maiden Lane, New York.
Stilwell, Bierce & Smith-Vaile Co., Dayton, O.
Vilter Manufacturing Co., Milwaukee, Wis.
Westinghouse Machine Co., Pittsburg, Pa.
Fred. W. Wolf Co., 139 Rees St., Chicago, Ill.

Ice and Refrigeration.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.
Fred W. Wolf Co., 139 Rees St., Chicago, Ill.

Impulse Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Incandescent Lamps.
Central Electric Co., 265-269 Fifth Ave., Chicago, Ill.
Pelton Engineering Co., Cleveland, Ohio.
Sawyer-Man Electric Co., New York.

Industrial Railways.
C. W. Hunt Co., West New Brighton, New York.
Whiting Foundry Equipment Co., Harvey, Ill.
Arthur Koppel, 68 Broad St., New York.

Injectors.
American Injector Co., Detroit, Mich.
The Lukenheimer Co., Cincinnati, Ohio.
Penberthy Injector Co., Detroit, Mich.
Wm. Sellers & Co., Philadelphia, Pa.

Insulated Wire.
Central Electric Co., 265-269 Fifth Ave., Chicago, Ill.
Okonite Co., Ltd., 253 Broadway, New York.
John A. Roebling's Sons Co., Trenton, N. J.

Interior Conduits.
Sprague Electric Co., 527 W. Thirty-fourth St., New York.

Iron.
Passaic Rolling Mill Co., Paterson, N. J.

Joists, Iron and Steel.
Chester B. Albree, Allegheny, Pa.
Passaic Rolling Mill Co., Paterson, N. J.

Kiers.
Atlantic Works, East Boston, Mass.

Kyanizing.
Otis Allen & Son, Lowell, Mass.

Lace Leather.
Chas. A. Schieren & Co., 45-51 Ferry St., New York.

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Lamps, Electric.
Central Electric Co., 265-269 Fifth Ave., Chicago, Ill.
Pelton Engineering Co., Cleveland, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Lathes.
American Tool Works Co. Cincinnati, Ohio.
U. Baird Machinery Co., Pittsburg, Pa.
W. F. & John Barnes Co., Rockford, Ill.
Bement, Miles & Co., Philadelphia, Pa.
Cincinnati Milling Machine Co., Cincinnati, O.
Jones & Lamson Machine Co., Springfield, Vt.
Niles Tool Works, Hamilton, Ohio.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Launches—Steam, Naphtha, etc.
Marine Iron Works, Station A, Chicago, Ill.

Leather, Hydraulic, Valve and Pump.
Chas. A. Schieren & Co., 45-51 Ferry St., New York.

Leather Link-Belting.
Chas. A. Schieren & Co., 45-51 Ferry St., New York.

Link Belting.
Buhl Malleable Co., Detroit, Mich.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.

Locomotives.
Baldwin Locomotive Works, Philadelphia, Pa.
Pittsburg Locomotive Works, Pittsburg, Pa.
H. K. Porter Co., Pittsburg, Pa.
Stearns Manufacturing Co., Erie, Pa.

Locomotive Brakes.
Westinghouse Air Brake Co., Pittsburg, Pa.

Locomotive Cranes.
Bucyrus Co., So. Milwaukee, Wis.

Lubricants.
Jos. Dixon Crucible Co., Jersey City, N. J.
Keystone Lubricating Co., Allegheny Ave., Philadelphia, Pa.

Machine Screws.
Worcester Machine Screw Co., Worcester, Mass.

Machine Tools and Supplies.
Acme Machinery Co., Cleveland, Ohio.
U. Baird Machinery Co., Pittsburg, Pa.
W. F. & John Barnes Co., Rockford, Ill.
Bement, Miles & Co., Philadelphia, Pa.
Billings & Spencer Co., Hartford, Conn.
Cincinnati Milling Machine Co., Cincinnati, O.
Fox Machine Co., Grand Rapids, Mich.
Hammacher, Schlemmer & Co., 209 Bowery, N.Y.
Hill, Clarke & Co., Oliver St., Boston, Mass.
Jones & Lamson Machine Co., Springfield, Vt.
Niles Tool Works, Hamilton, Ohio.
Norton & Jones Machine Tool Works, Plainville, Conn.
O & C Company, Chicago, Ill.
Wm. Sellers & Co., Philadelphia, Pa.
Stearns Manufacturing Co., Erie, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Walworth Manufacturing Co., Boston, Mass.
Warner & Swasey, Cleveland, Ohio
Worcester Machine Screw Co., Worcester, Mass.

Malleable Castings.
Buhl Malleable Co., Detroit, Mich.

Manganese Bronze.
Paul S. Reeves & Son, Philadelphia, Pa.

Marine Boilers.
Marine Iron Works, Station A, Chicago, Ill.

Marine Machinery.
Lambert Hoisting Engine Co., Newark, N. J.
Marine Iron Works, Station A, Chicago, Ill.

Mathematical Instruments.
Theo. Alteneder & Sons, Philadelphia, Pa.
Brandis Sons Co., Brooklyn, N. Y.
Queen & Co., Inc., Philadelphia, Pa.

Mechanical Draft.
American Blower Co., Detroit, Mich.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Merchant Steel.
Wm. Jessop & Sons, Ltd., 91 John St., N. Y.

Metals.
Passaic Rolling Mill Co., Paterson, N. J.
Phosphor Bronze Smelting Co., Ltd., Phila., Pa.

Metal Lath.
Cincinnati Corrugating Co., Piqua, Ohio.

Metal Punching and Shearing.
Harrington & King Perforating Co., Chicago, Ill.

Metallic Packing.
United States Metallic Packing Co., Philadelphia, Pa.

Meters, Electric.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Weston Electrical Instrument Co., Newark, N. J.

Milling Machines.
American Tool Works Co., Cincinnati, Ohio.
Bement, Miles & Co., Philadelphia, Pa.
Cincinnati Milling Machine Co., Cincinnati, O.
Fox Machine Co., Grand Rapids, Mich.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Milling Tools.
John M. Rogers, Boat, Gauge and Drill Works, Gloucester City, N. J.

Mine Cars.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
C. W. Hunt Co., West New Brighton, New York.
Jeffrey Manufacturing Co., Columbus, Ohio.
Arthur Koppel, 68 Broad St., New York.
Whiting Foundry Equipment Co., Harvey, Ill.

Mining Machinery.
Edw. P. Allis Co., So. Milwaukee, Wis.
American Hoist & Derrick Co., St. Paul, Minn.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Arthur Koppel, 68 Broad St., New York.
Lambert Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., 96 Liberty St., New York.
John H. McGowan Co., Cincinnati, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
Rand Drill Co., 100 Broadway, New York.
Robins Conveying Belt Co., Park Row Building, New York.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.
Weber Gas & Gasoline Engine Co., 428 Southwest Boulevard, Kansas City, Mo.
Webster, Camp & Lane Machine Co., Akron, O.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Mining Screens.
Aultman Company, Canton, Ohio.
Fraser & Chalmers, Chicago, Ill.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.

Motors, Electric.
American Engine Co., Bound Brook, N. J.
C & C Electric Co., 145 Liberty St., New York.
Commercial Electric Co., Indianapolis, Ind.
Eddy Electric Mfg. Co., Windsor, Conn.

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General Electric Co., New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Pelton Engineering Co., Cleveland, Ohio.
Sprague Electric Co., 527 West Thirty-fourth St., New York.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Triumph Electric Co., Cincinnati, Ohio.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Multiple Drills.
Bickford Drill and Tool Co., Cincinnati, Ohio.
Foote, Burt & Co., Cleveland, Ohio.

Naphtha Gas Machines.
American Gas Furnace Co., 23 John St., N. Y.

Nickel.
Canadian Copper Co., Cleveland, Ohio.
Orford Copper Co., 37 Wall St., New York.

Nickel-Steel.
Bethlehem Steel Co., South Bethlehem, Pa.

Office Furniture.
Library Bureau, Boston, Mass.
Rockwell & Rupel Co., 53 La Salle St., Chicago.

Oil Cups.
The Lukenheimer Co., Cincinnati, Ohio.
Walworth Manufacturing Co., Boston, Mass.

Oil Extractors.
Direct Separator Co., Syracuse, N. Y.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.

Oil-Gas Plants.
American Gas Furnace Co., 23 John St., N. Y.

Oil Separators.
American Tool Works Co., Cincinnati, Ohio.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Harrison Safety Boiler Works, Philadelphia, Pa.

Open Hearth Furnaces.
Whiting Foundry Equipment Co., Harvey, Ill.

Ore-Dressing Machinery.
Fraser & Chalmers, Chicago, Ill.

Ore-Roasting Machinery.
F. D. Cummer & Son Co., Cleveland, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Ore Screens.
Jeffrey Manufacturing Co., Columbus, Ohio.
Harrington & King Perforating Co., Chicago, Ill.

Packing.
Boston Belting Co., Boston, Mass.
Jenkins Brothers, 71 John St., New York.
United States Metallic Packing Co., Philadelphia, Pa.

Paddle-Wheel Machinery.
Marine Boiler Works, Station A, Chicago, Ill.

Paints.
Detroit Graphite Mfg. Co., Detroit, Mich.
Joseph Dixon Crucible Co., Jersey City, N. J.
Harrison Bros. & Co., Inc., Philadelphia, Pa.

Paper-Mill Machinery.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
Robins Conveying Belt Co., Park Row Building, New York.
Robt. Wetherill & Co., Chester, Pa.

Pattern-Makers' Machinery.
Egan Co., 271-921 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.

Pattern Makers' Tools.
Fox Machine Co., Grand Rapids, Mich.

Penstocks.
Atlantic Works, East Boston, Mass.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Perforated Metals.
Fraser & Chalmers, Chicago, Ill.
Harrington & King Perforating Co., Chicago, Ill.

Peroxide of Sodium.
Roessler & Hasslacher Chemical Co., New York.

Phosphor Bronze.
Phosphor Bronze Smelting Co., Ltd., Phila., Pa.
Paul S. Reeves & Son, Philadelphia, Pa.

Photographic Supplies.
Queen & Co., Inc., Philadelphia, Pa.

Pile Drivers.
Bucyrus Co., So. Milwaukee, Wis.

Pipe, Cast-Iron.
Jeanesville Iron Works, Jeanesville, Pa.
Walworth Manufacturing Co., Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.
U. S. Cast Iron Pipe & Fdy. Co., Philadelphia Pa.

Pipe Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Pipe Coverings.
Michigan Pipe Co., Bay City, Mich.

Pipe-Cutting and Threading Machines.
Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Cox & Sons Company, Bridgeton, N. J.
Walworth Manufacturing Co., Boston, Mass.

Pipe Dies.
Walworth Manufacturing Co., Boston, Mass.

Pipe Fittings, Cast-Iron.
Walworth Manufacturing Co., Boston, Mass.

Pipe Foundry Equipment.
Whiting Foundry Equipment Co., Harvey, Ill.

Pipe, Wrought-Iron.
Walworth Manufacturing Co., Boston, Mass.

Piston Rods.
Bethlehem Steel Co., South Bethlehem, Pa.

Placer Mining Machinery.
Bucyrus Co., So. Milwaukee, Wis.

Planers.
American Tool Works Co., Cincinnati, Ohio.
U. Baird Machinery Co., Pittsburg, Pa.
Bement, Miles & Co., Philadelphia, Pa.
Cincinnati Milling Machine Co., Cincinnati, O.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Planing Mill Machinery.
Egan Co., 271-921 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.

Platinum Ware.
J. C. Entriken, Malvern, Pa.

Plumbers' Tools and Supplies.
Walworth Manufacturing Co., Boston, Mass.

Pneumatic Tools.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.

Portable Railways.
C. W. Hunt Co., West New Brighton, New York.
Arthur Koppel, 68 Broad St., New York.

Portland Cement.
Atlas Portland Cement Co., 143 Liberty St., New York.

Power Hammers.
Bement, Miles & Co., Philadelphia, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Power Punches and Shears.
Ferracute Machine Co., Bridgeton, N. J.
Fox Machine Co., Grand Rapids, Mich.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Power-Transmission Machinery.
Aultman Company, Canton, Ohio.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.
Robins Conveying Belt Co., Park Row Building, New York.
Sprague Electric Co., 527 W. Thirty-fourth St., New York.
Triumph Electric Co., Cincinnati, Ohio.

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Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Preservation of Lumber.
Otis Allen & Son, Lowell, Mass.

Presses and Dies.
Ferracute Machine Co., Bridgeton, N. J.

Presses, Hydraulic, etc.
Watson & Stillman Co., 210 East 43d St., New York.
R. D. Wood & Co., Philadelphia, Pa.

Propeller Wheels.
Marine Iron Works, Station A, Chicago, Ill.

Prospecting Drills.
American Well Works, Aurora, Ill.
Star Drilling Machine Co., Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Pulley Cover.
Warren Mfg. Co., 71 So. Canal St., Chicago, Ill

Pulleys, Shafting and Hangers.
Edw. P. Allis Co., Milwaukee, Wis.
Aultman Company, Canton, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
R. Poole & Son Co., Baltimore, Md.
Reeves Pulley Co., Columbus, Ind.
Robins Conveying Belt Co., Park Row Building, New York.
Wm. Sellers & Co., Philadelphia, Pa.
Robert Wetherill & Co., Chester, Pa.

Pulverizers.
Fraser & Chalmers, Chicago, Ill.
Jeffrey Manufacturing Co., Columbus, Ohio.
Sturtevant Mill Co., Boston, Mass.

Pumps and Pumping Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
American Well Works, Aurora, Ill.
Barr Pumping Engine Co., Philadelphia, Pa.
The Geo. F. Blake Mfg. Co., 91 Liberty St., New York.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Cook Well Co., St. Louis, Mo.
Davis, Johnson & Co., Station U, Chicago, Ill.
The Deane Steam Pump Co. of Holyoke, 120 Liberty St., New York.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Guild & Garrison, Brooklyn, N. Y.
The Holly Manufacturing Co., 120 Liberty St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Jeanesville Iron Works, Jeanesville, Pa.
John H. McGowan Co., Cincinnati, Ohio.
Knowles Steam Pump Works, 91 Liberty St., New York.
The Laidlaw-Dunn-Gordon Co., 120 Liberty St., New York.
Merrill Pneumatic Pump Co., 143 Broadway, New York.
Pulsometer Steam Pump Co., 120 Liberty St., New York.
Wm. E. Quimby, 86 Liberty St., New York.
Scranton Steam Pump Co., Scranton, Penna.
Snider-Hughes Co., Cleveland, Ohio.
Snow Steam Pump Works, 120 Liberty St., New York.
Stilwell-Bierce & Smith Vaile Co., Dayton, Ohio.
Weber Gas & Gasoline Engine Co., 428 Southwest Boulevard, Kansas City, Mo.
Webster, Camp & Lane Machine Co., Akron, Ohio.
R. D. Wood & Co., Philadelphia, Pa.
Henry R. Worthington, 120 Liberty St., New York.

Punching and Shearing Machinery.
American Tool Works Co., Cincinnati, Ohio.
U. Baird Machinery Co., 723-725 Water St., Pittsburg, Pa.
Bement, Miles & Co., Philadelphia, Pa.
Fuller Mfg. Co., Kalamazoo, Mich.
Fox Machine Co., Grand Rapids, Mich.

Quarrying Machinery.
American Hoist & Derrick Co., St. Paul, Minn.
A. S. Cameron Steam Pump Works, E. 23d St., New York.
Cooper, Hewitt & Co., 17 Burling Slip, N. Y.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
John H. McGowan Co., Cincinnati, Ohio.
Rand Drill Co., 100 Broadway, New York.
Robins Conveying Belt Co., Park Row Building, New York.
Sullivan Machinery Co., Chicago, Ill.
Trenton Iron Co., Trenton, N. J.

Radiator Screens.
Harrington & King Perforating Co., Chicago, Ill.

Radiators.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City, N. J.
H. B. Smith Co., 137 Centre St., New York.

Radial Drills.
American Tool Works Co., Cincinnati, Ohio.
Bickford Drill and Tool Co., Cincinnati, Ohio.

Railroad Ditchers.
Jeffrey Mfg. Co., Cleveland, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
Robins Conveying Belt Co., Park Row Building, New York.
Vulcan Iron Works, Toledo, Ohio.

Railway-Car Brakes.
Westinghouse Air Brake Co., Pittsburg, Pa.

Railway Feed Wires.
Okonite Co., Ltd., 253 Broadway, New York.

Railway Shop Machinery.
Chester B. Albree, Allegheny, Pa.
Armstrong Mfg. Co., Bridgeport, Conn.
U. Baird Machinery Co., 723-725 Water St., Pittsburg, Pa.
W. F. & John Barnes Co. Rockford, Ill.
Egan Co., 271-921 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.
Niles Tool Works, Hamilton, Ohio.
Norwalk Iron Works, South Norwalk, Conn.
O & C Company, Chicago, Ill.
Stow Flexible Shaft Co., Philadelphia, Pa.
Stow Manufacturing Co., Binghamton, N. Y.
Watson & Stillman Co., 210 E. 43d St., New York.

Railway Specialties.
Dorner Truck & Mfg. Co., Cleveland, Ohio.
Goodwin Car Co., 96 Fifth Ave., New York.
Arthur Koppel, 68 Broad St., New York.
H. K. Porter & Co., Pittsburg, Pa.,
O & C Company, Chicago, Ill.
Westinghouse Air Brake Co., Pittsburg, Pa.

Railways, Portable.
C. W. Hunt Co., West New Brighton, New York.
Arthur Koppel, 68 Broad St., New York.

Rawhide Pinions.
New Process Rawhide Co., Syracuse, N. Y.

Refrigerating Machinery.
Frick Company, Waynesboro, Pa.

Riveting Machines.
Chester B. Albree, Allegheny, Pa.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Road-Making Machinery.
Aultman Co., Canton, Ohio.
O. S. Kelly Co., Springfield, Ohio.
Marion Steam Shovel Co., Marion, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Road Rollers.
Aultman Co., Canton, Ohio.
O. S. Kelly Co., Springfield, Ohio.

Rock Breakers.
Aultman Co., Canton, Ohio.
Edw. P. Allis Co., Milwaukee, Wis.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Robins Conveying Belt Co., Park Row Building, New York.

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Rock Drills.
M. C. Bullock Mfg. Co., Chicago, Ill.
Clayton Air Compressor Works, 20 Cortlandt St., New York.
Ingersoll-Sergeant Drill Co., 26 Cortlandt St., New York.
Rand Drill Co., 100 Broadway, New York.
Star Drilling Machine Co., Akron, Ohio.
Sullivan Machinery Co., Chicago, Ill.

Roofing.
Cincinnati Corrugating Co., Piqua, Ohio.
Merchant & Co., Philadelphia, Pa.
Passaic Rolling Mill Co., Paterson, N. J.

Roofs, Iron Truss.
Passaic Rolling Mill Co., Paterson, N. J.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Rope.
American Manuacturing Co., 63 Wall St., New York.

Rope Transmission.
Aultman Company, Canton, Ohio.
C. W. Hunt Co., West New Brighton, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.
Link-Belt Engineering Co., Philadelphia, Pa.

Rubber Goods.
Boston Belting Co., Boston, Mass.
Jenkins Brothers, 71 John St., New York.

Saw-Mill Machinery.
Edw. P. Allis Co., Milwaukee, Wis.
The Egan Co., 271-291 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.
Jeffrey Manufacturing Co., Columbus, Ohio.

Schools.
Harvard University, Cambridge, Mass.
International Correspondence Schools, Scranton, Pa.
Rensselaer Polytechnic Institute, Troy, N. Y.
University of Wisconsin, Madison, Wis.

Screens, Mining.
Aultman Company, Canton, Ohio.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Mfg. Co., Columbus, Ohio.
Robins Conveying Belt Co., Park Row Building, New York.

Screw Machines.
American Tool Works Co., Cincinnati, Ohio.
Cincinnati Milling Machine Co., Cincinnati, O.
Jones & Lamson Machine Co., Springfield, Vt.
Niles Tool Works, Hamilton, Ohio.
Warner & Swasey, Cleveland, Ohio.

Screw-Cutting Machinery.
American Tool Works Co., Cincinnati, Ohio.
U. Baird Machinery Co., 723-725 Water St., Pittsburg, Pa.

Sensitive Drills.
American Tool Works Co., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.
Knecht Bros. Co., Cincinnati, Ohio.

Separators, Coal and Ore.
F. D. Cummer & Son Co., Cleveland, Ohio.
Harrington & King Perforating Co., Chicago, Ill.
Jeffrey Manufacturing Co., Columbus, Ohio.

Separators, Steam.
Direct Separator Co., Syracuse, N. Y.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
Harrison Safety Boiler Works, Philadelphia, Pa.
Taunton Locomotive Mfg. Co., Taunton, Mass.

Shafts—Flexible.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

Shafts, Solid and Hollow.
Bethlehem Steel Co., South Bethlehem, Pa.

Shafting (see Pulleys).

Shapers.
American Tool Works Co., Cincinnati, Ohio.
U. Baird Machinery Co., 723-725 Water St., Pittsburg, Pa.
Cincinnati Milling Machine Co., Cincinnati, Ohio.
Cincinnati Shaper Co., Cincinnati, Ohio.
Fox Machine Co., Grand Rapids, Mich.
Wm. Sellers & Co., Inc., Philadelphia, Pa.

Sheet-Metal Tools.
Ferracute Machine Co., Bridgeton, N. J.

Shoes and Dies.
Chrome Steel Works, Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Gates Iron Works, Chicago, Ill.

Smokestacks.
Clonbrock Steam Boiler Co., Brooklyn, N. Y.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Sodium Peroxide.
Roessler & Hasslacher Chem. Co., 100 William St., New York.

Spark Guards, Perforated.
Harrington & King Perforating Co., Chicago, Ill.

Stand Pipes.
Riter-Conley Mfg. Co., Pittsburg, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Steam Joint Clamp.
James McCrea & Co., 11-17 So. Canal St., Chicago, Ill.

Steam Loops.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Steam-Regulating Appliances.
Harrison Safety Boiler Works, Philadelphia, Pa.
Jenkins Brothers, 71 John St., New York.
The Lukenheimer Co., Cincinnati, Ohio.
Walworth Manufacturing Co., Boston, Mass.

Steamships and Towboats.
Atlantic Works, East Boston, Mass.

Steam Shovels.
Bucyrus Co., So. Milwaukee, Wis.
Marion Steam Shovel Co., Marion, Ohio.
Vulcan Iron Works, Toledo, Ohio.

Steam Traps.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.
Walworth Manufacturing Co., Boston, Mass.

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Cleveland Ball & Screw Co., Cleveland, Ohio.

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Wm. Jessop & Sons, Ltd., 91 John St., New York.

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Chrome Steel Works, Brooklyn, N. Y.
Hobson, Seaman & Co., 97 John St., New York.
Wm. Jessop & Sons, Ltd., 91 John St., New York.
Latrobe Steel Co., Philadelphia, Pa.
Passaic Rolling Mill Co., Paterson, N. J.

Stokers.
Wm. Sellers & Co., Inc., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.
Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York.

Structural Iron Work.
Chester B. Albree, Allegheny, Pa.
Berlin Iron Bridge Co., East Berlin, Conn.
Passaic Rolling Mill Co., Paterson, N. J.
Riter-Conley Mfg. Co., Pittsburg, Pa.

Sugar-House Machinery.
Jeffrey Manufacturing Co., Columbus, Ohio.
Henry G. Morris, Philadelphia, Pa.
Robins Conveying Belt Co., Park Row Building, New York.
Fred. W. Wolf Co., 130 Rees St., Chicago, Ill.
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Keuffel & Esser Co., New York.

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Aultman Company, Canton, Ohio.
Clonbrock Steam Boiler Co., Brooklyn, N. Y.
Fraser & Chalmers, Chicago, Ill.
Pittsburg Locomotive Works, Pittsburg, Pa.
Riter-Conley Mfg. Co., Pittsburg, Pa.
Taunton Locomotive Mfg. Co., Taunton, Mass

Tapping and Reaming Machines.
Philadelphia Pneumatic Tool Co., Philadelphia, Pa.
Stow Flexible Shaft Co., Philadelphia, Pa.

Telegraph Wires and Cables.
Okonite Co., New York.

Telephones.
Central Electric Co., 265-269 Fifth Ave., Chicago, Ill.
Eureka Electric Co., 157 So. Canal St., Chicago, Ill.
Frank H. Stewart & Co., 35 N. 7th St., Philadelphia, Pa.
Tucker Manufacturing Co., York, Pa.

Tenoning Machines.
The Egan Co., 271-291 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.

Testing Machinery.
Wm. Sellers & Co., Philadelphia, Pa.

Thermometers.
Bristol Co., Waterbury, Conn.
Hohmann & Maurer Mfg. Co., 53 Elizabeth St., Rochester, N. Y.
Queen & Co., Inc., Philadelphia, Pa.

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O & C Company, Chicago, Ill.

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C. W. Hunt Co., West New Brighton, New York.
Arthur Koppel, 68 Broad St., New York.

Tramways, Wire Rope.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
W. Dusedau, 36 Pilling St., Brooklyn, N. Y.
C. W. Hunt Co., West New Brighton, New York.
Trenton Iron Co., Trenton, N. J.

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Tube Cleaners.
Union Boiler Tube Cleaner Co., Pittsburg, Pa.

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Christiana Machine Co., Christiana, Pa.
James Leffel & Co., Springfield, Ohio.
S. Morgan Smith Co., York, Pa.
Pelton Water Wheel Co., San Francisco, Cal.
R. Poole & Son Co., Baltimore, Md.
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Warner & Swasey, Cleveland, Ohio.

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Morse Twist Drill & Mach. Co., New Bedford, Mass.

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Henry G. Morris, Philadelphia, Pa.

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Clayton Air Compressor Works, 26 Cortlandt St., New York.
Deane Steam Pump Co., Holyoke, Mass.
Guild & Garrison, Brooklyn, N. Y.
John H. McGowan Co., Cincinnati, Ohio.

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Harrison Bros. & Co., Inc., Philadelphia, Pa

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Jeanesville Iron Works, Jeanesville, Pa.
Jenkins Brothers, 71 John St., New York.
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John H. McGowan Co., Cincinnati, Ohio.
Wm. Powell Co., Cincinnati, Ohio.
Ross Valve Co., Troy, N. Y.
Walworth Mfg. Co., Boston, Mass.
R. D. Wood & Co., Philadelphia, Pa.

Ventilating Appliances.
American Blower Co., Detroit, Mich.
Buffalo Forge Co., Buffalo, N. Y.
A. A. Griffing Iron Co., 66-68 Centre St., New York; Works, Jersey City.
B. F. Sturtevant Co., Jamaica Plain Station, Boston, Mass.

Voltmeters.
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Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Weston Electrical Instrument Co., Newark, N. J.

Watt Meters.
Buffalo Meter Co., Buffalo, N. Y.
Pittsburg Meter Co., East Pittsburg, Pa.

Water-Tube Boilers.
The Stirling Co., Chicago, Ill.

Water Works Supplies.
American Well Works, Aurora, Ill.
Star Drilling Machine Co., Akron, Ohio.
U. S. Cast Iron Pipe & Foundry Co., Phila., Pa.
R. D. Wood & Co., Philadelphia, Pa.

Water Wheels.
Christiana Machine Co., Christiana, Pa.
James Leffel & Co., Springfield, Ohio.
Pelton Water Wheel Co., San Francisco, Cal.
S. Morgan Smith Co., York, Pa.
R. Poole & Son Co., Baltimore, Md.
R. D. Wood & Co., Philadelphia, Pa.

Water-Works Pumping Machinery.
Fraser & Chalmers, Chicago, Ill.
John H. McGowan Co., Cincinnati, Ohio.

Weldless Steel Flanges.
Latrobe Steel Co., 1200 Girard Bldg., Philadelphia, Pa.

Well-Sinking Machinery.
American Well Works, Aurora, Ill.
Star Drilling Machine Co., Akron, Ohio.
Williams Bros., Ithaca, N. Y.

Wire.
Phosphor Bronze Smelting Co., Ltd., Philadelphia, Pa.

Wire Cloth.
Phosphor Bronze Smelting Co., Ltd., Philadelphia, Pa.

Wire, Iron, Steel and Copper.
John A. Roebling's Sons Co., Trenton, N. J.

Wire Rope.
Cooper, Hewitt & Co., 17 Burling Slip, New York.
Jeffrey Mfg. Co., Columbus, Ohio.
Phosphor Bronze Smelting Co., Ltd., Philadelphia, Pa.
John A. Roebling's Sons Co., Trenton, N. J.
Trenton Iron Co., Trenton, N. J.

Wire Rope Tramways.
John A. Roebling's Sons Co., Trenton, N. J.

Wood Split Pulleys.
W. A. Jones Foundry and Machine Co., 53-59 So. Jefferson St., Chicago, Ill.

Wood-Working Machinery.
Egan Co., 271-921 West Front St., Cincinnati, Ohio.
J. A. Fay & Co., 271-291 West Front St., Cincinnati, Ohio.
Stow Flexible Shaft Co., Philadelphia, Pa.

Wrecking Cars.
Bucyrus Co., So. Milwaukee, Wis.
Marion Steam Shovel Co., Marion, Ohio.

Yachts.
Atlantic Works, East Boston, Mass.
Marine Iron Works, Station A, Chicago, Ill.

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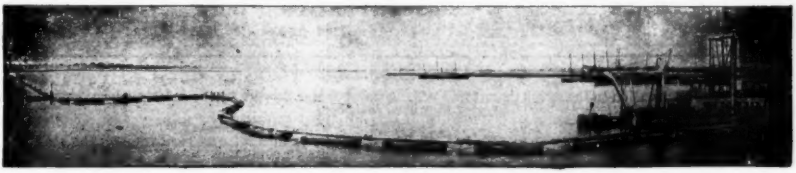
New York Dredging Co.,



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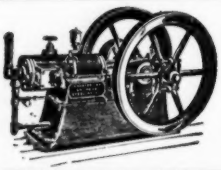

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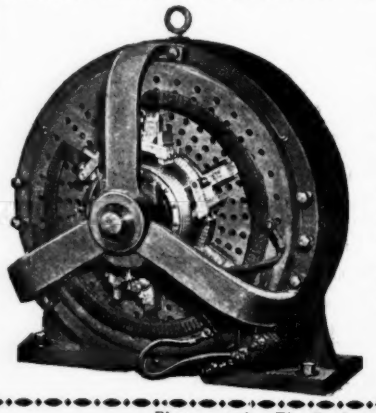

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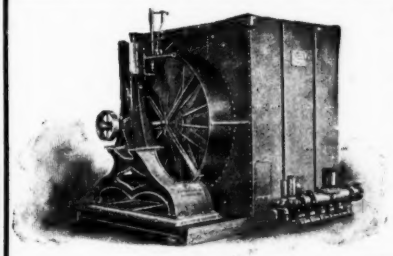

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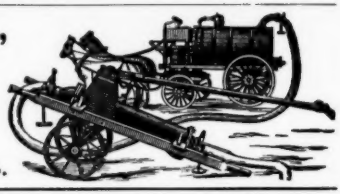

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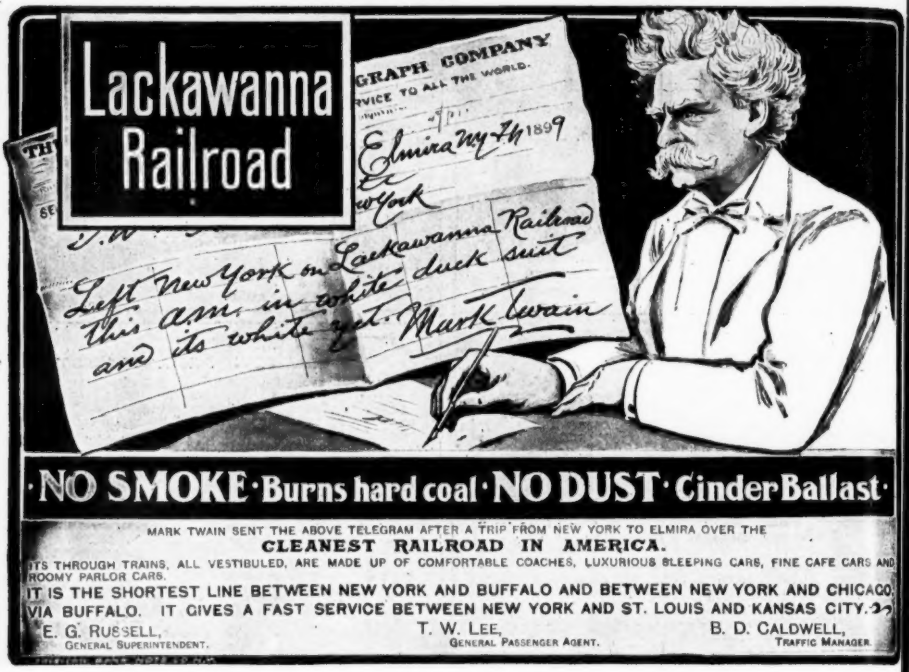
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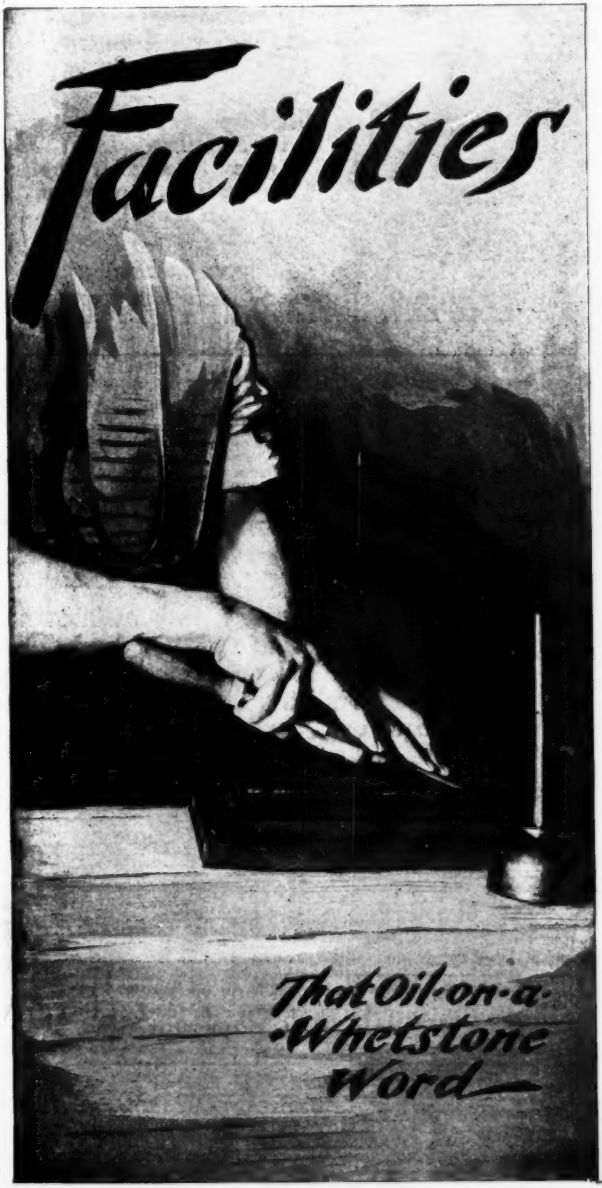

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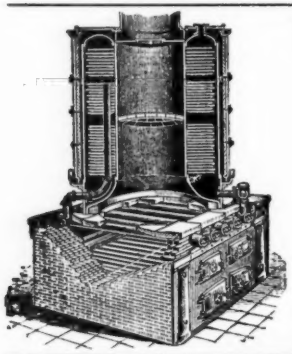

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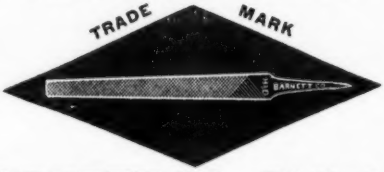

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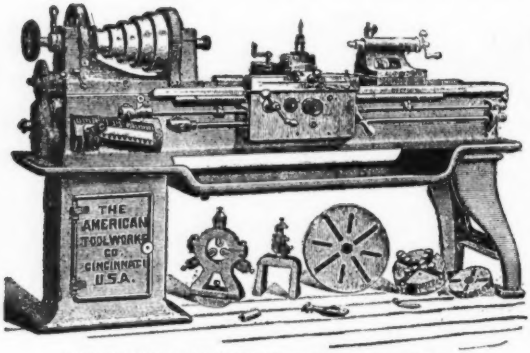

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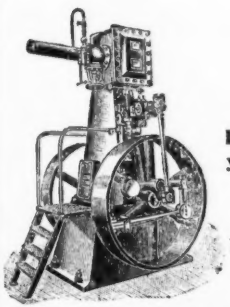

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